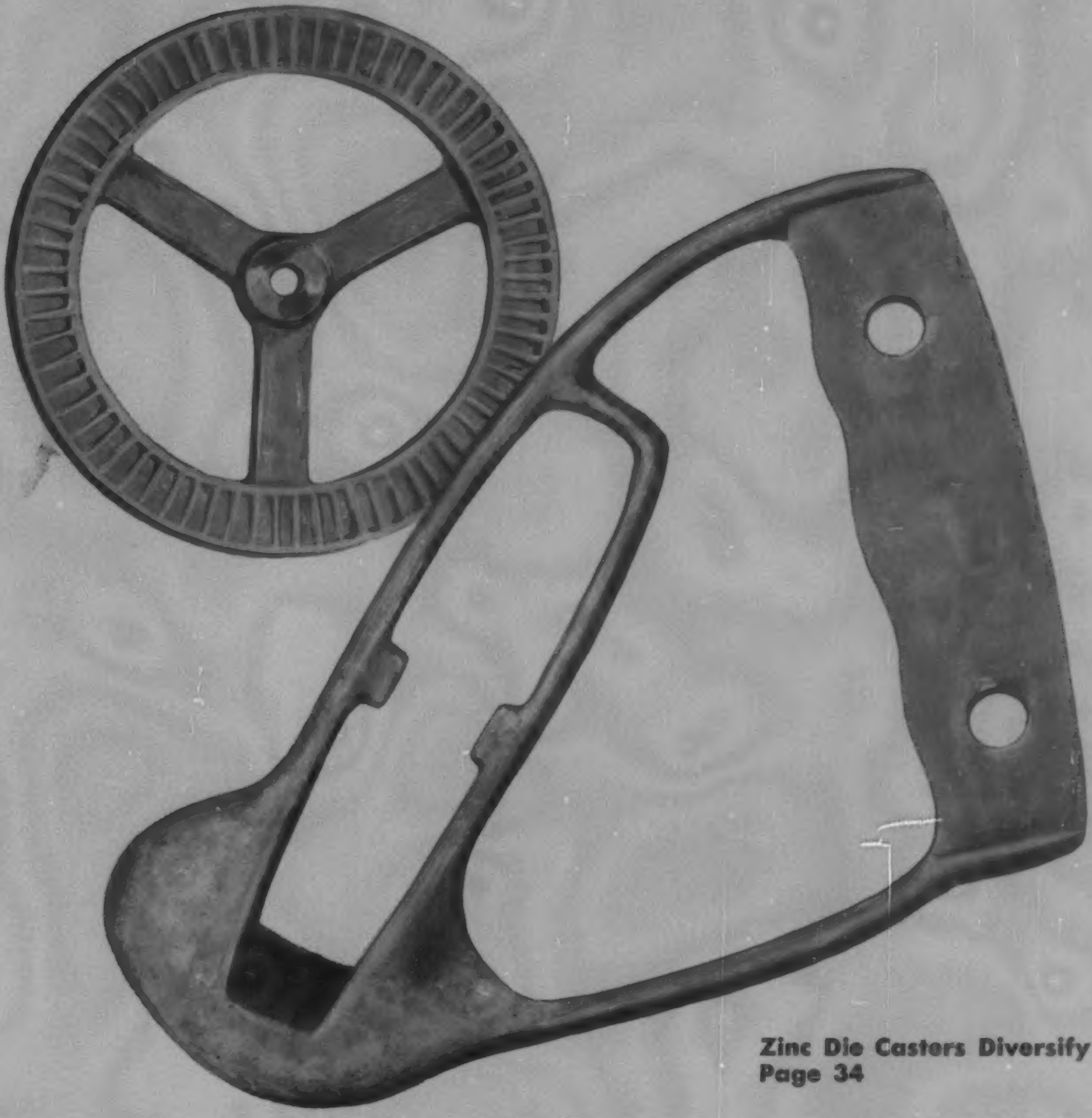
AUGUST 1961

modern castings

the technology-for-profit magazine



Zinc Die Casters Diversify
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How Carbon Sand Delivers On-the-Job Economy 31

How to Improve Aluminum by Centrifugal Casting 98

How to Plan for Capital Expenditures 42

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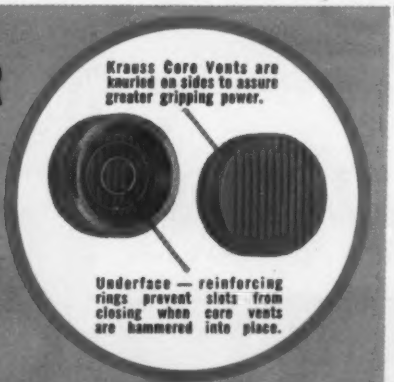

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Circle No. 122, Pages 133-134

Circle No. 123, Pages 133-134

August 1961 Vol. 40, No. 2

modern castings

metalcasting "technology-for-profit"

COVER

Drawn by CHARLES ROTH. Two zinc die castings—parts of an egg beater assembly—represent the growing non-automotive market opening for zinc. See story on page 34.

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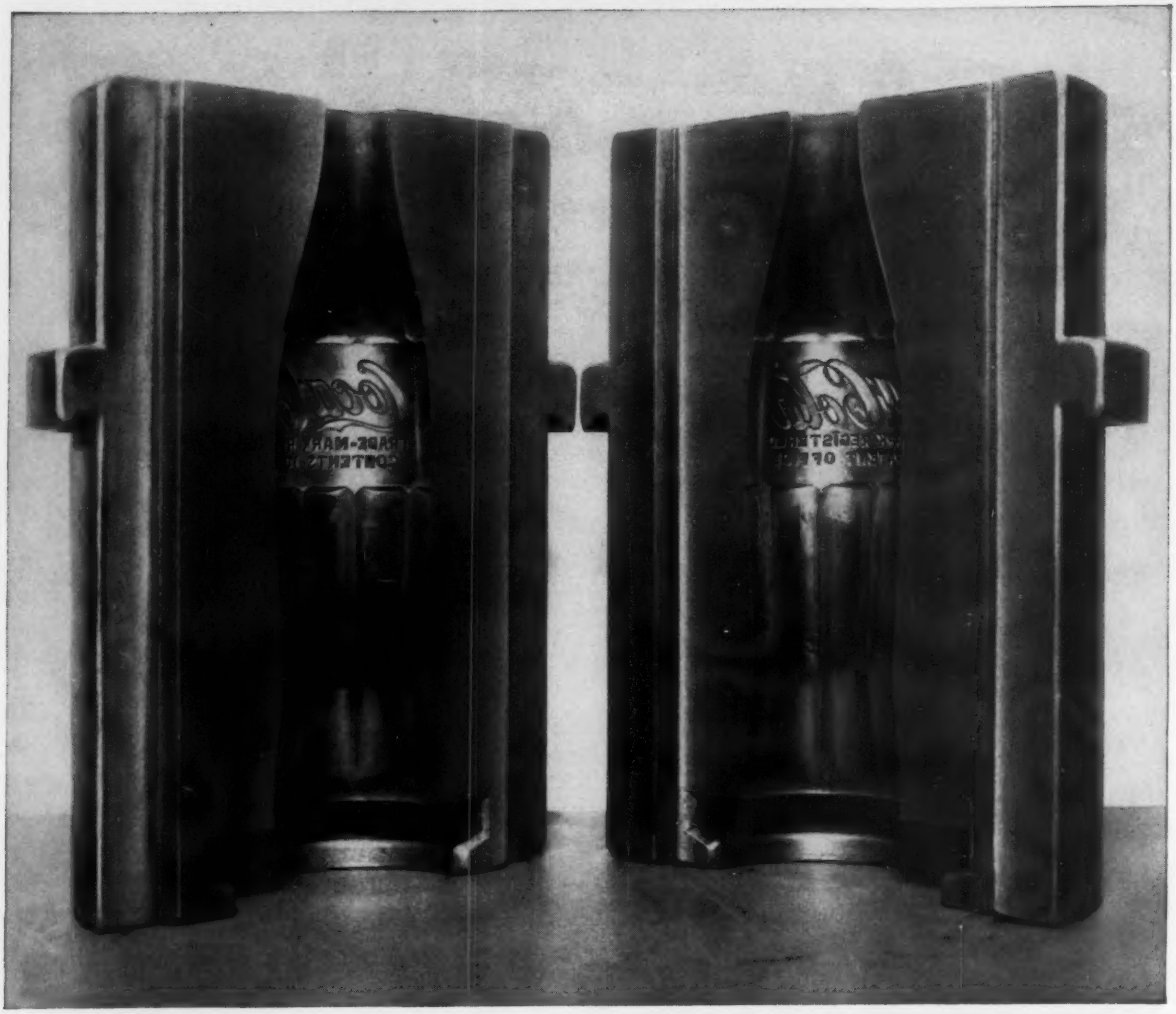

Nickel cast iron helps Coke get over 5 million bottles per mold

Demonstrates advantages of nickel-alloyed iron for foundrymen and users of castings

Bottles for Coca-Cola* are made in nickel cast iron molds for two important reasons. Nickel cast iron molds have the right combination of engineering properties to assure bottles of a high quality. And nickel cast iron molds have the stamina and strength to assure a long service life... more than 5 million bottles per mold.

You and your customers benefit when you add nickel to iron castings

Nickel helps give Coca-Cola bottle molds a dense, close-grained structure ... particularly on the chilled cavity which comes in contact with molten glass. And by giving you, the foundrymen, better control over castings, nickel helps you cut castings rejects to a minimum.

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Write Inco for helpful information

Whether you make glass molds or any other type of iron castings, there's a good chance that nickel can help you improve them. For detailed information on the family of nickel cast irons, just drop a note to Inco, c/o Foundry Industry Manager, outlining your problems with iron castings. Perhaps Inco nickel and Inco Research can help you solve them.

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Published by

American Foundrymen's Society

GENERAL MANAGER
WM. W. MALONEY

Let's look at . . .

It's Either Up or Down!

H. E. Green

The big news this month can be found on page 116. A real victory has been won by the American Foundrymen's Society after many years of effort and discussion. The government has ruled that the Technical and Research Institute of AFS is not subject to taxation on any funds provided it for research activities. For some time now the metalcasting industry has vitally needed a training center. The more glamorous industries have been getting the nod from educational institutions. T&RI now provides a dramatic focus for training and product development.

Incidentally this issue provides a well balanced mixture of editorial and news. For instance:

. . . New strides are being made by zinc die casters in growing market areas, page 34.

. . . Up-to-the-minute New Technology—the use of carbon sand saves time and money. A 1961 Breakthrough, page 31.

. . . A complete report on the International Foundry Congress held in Vienna, Austria, pages 118 and 119.

Also recommended for August issue reading is the Trends in Education Column by Ralph Betterley on page 20.

Next month Modern Castings introduces still another important feature of interest. Our Washington editor, W. R. Fingal, will present a new interpretative news report, "Metalcasting and Washington." The son of a metalcaster, Mr. Fingal is a long-time veteran observer of the Washington scene. The combination of backgrounds will indeed prove beneficial, I am sure. Watch for it every month!

Harold E Green

Looking at Business with Modern Castings

AUTOMOTIVE

You can be optimistic about the coming surge in business. But you should watch the bellwether industries carefully. Inflation is just ahead-and what you will get for your profit pocket may be smaller than you think. Some companies are quietly—some not so quietly because they're in the public eye—including plans to cope with inflation in the months ahead. Don't be caught napping.

Obviously the business pace is quickening. An expected fall pick-up is one reason. And you'll find additional strength as well. June shipments of durables were good. July and August are slow—and this has not been too surprising. However, keep your eye on the rate of gain.

September looks fairly good at this writing. The order flow for steel, copper shipments, machinery and other producer's equipment makes the fourth quarter look strong. Detroit and Defense hold the key for metalcasters.

Most economist predict a steady trend upward—fall to be brisk, winter good, and spring very good. Profits for the third quarter will be lower than most companies expected.

You will find order hesitancy here in many areas until negotiations between labor and the automotive companies on new work contracts are over. No one in his right mind would build up inventories if a strike might take place. The odds are against this—but who will take a chance and keep on buying parts or steel?

Automobile manufacturers are displaying optimism about the rest of the year. Industry sales are marching head. New car dealers seem pleased about the outlook—and there is much talk about a big year in 1962.

So-called deferred purchases are expected to take place in the month just ahead. Best guess is a fourth quarter surge for automobiles (and steel), with September showing up well compared to last year.

CONSTRUCTION

Thus far, activity has been slower than expected. Some encouraging signs are beginning to show up—and this affects many phases of metalcasting. The predictions for the last half of 1961:

You will find the emphasis, probably, on professional, institutional, and governmental facilities. The outlook

. . . Commercial building will hold firm despite some decline in new projects

. . . Institutional building will be up slightly

. . . Public building will be up rather strongly.

Industrial building will hold level with 1960, which is not too encouraging. Repairs and maintenance will be about the same as last year. Residential building is slated for a 5 percent drop.

Add this up, and the sum comes to about the same level of activity as took place in the last six months of 1960.

DEFENSE

Make no mistake about this: speed-up is taking place. Although aircraft and missiles will get good attention, you

will find that ground forces will be expanded. Equipment and material for such troops will be modernized. All this means an increase in employment and more money in consumer channels.

Signs:

Albion Malleable Iron Co., has just announced the receipt of a million dollar contract to produce mortar shells. Here's where replacement of forged steel shells by cast pearlitic malleable iron is producing new market opportunities for quality ordnance materials.

IF you want defense business, now is the time to find out what is happening—and where you can fit in. It takes time to develop firm contracts.

You will not find any indication of a slow up in Defense spending if present plans hold up.

CONSTRUCTION MACHINERY

A mixed picture here at present. You cannot find strong improvement except in highway construction—and the long range outlook depends on Federal Government legislation. Expect a modest increase in the months ahead. Steel and mining activity may provide some cues.

Look for varying conditions abroad from an import standpoint. Europe looks good, but other parts of the Free World are not promising. Expect a slight decline.

ELECTRICAL MACHINERY

You will find modest gains taking place here. Backlogs are being worked off now. Shipments will run ahead of new orders, but a slight drop is taking place in this third quarter. The fourth quarter will rectify this.

With appliances a factor in this field, what the consumer does in the next four months will be important. Here is a favorable sign. Incomes are at a new high. So is total spending. Job security is reported (see McGraw Hill's Survey on Consumer Attitudes and Intentions to Buy) as the assurance desired before the consumer spends more freely. The current tendency is toward non-durables rather than durables.

TRANSPORTATION

A big fat muddle! And Congress and the Administration are providing the muddle!

Despite headlines such as the New Haven & Hartford Railroad giving up the ghost, metalcasters can still find pleasing signs. (See our Market Opportunities report, page 31 July issue).

Economic recovery will be at a slower pace in the months ahead. But benefits will come from:

. . . Replenishment of inventories

. . . Expanding steel production

. . . Increasing foreign trade.

All this means increase in car loadings—and improvement and more maintenance of rolling stock.

The recent boost in trucking rates (up about 5 percent by the end of this year) should bring a slight shift in cargo to railroads.

A hard fact is that the entire transportation industry could be in better shape. Most common carriers—air, rails, highway, and water—are either making small profits or none at all.

As mentioned before, government holds the key. What they do about taxes and depreciation allowances will have much effect.

Around the World with Modern Castings

ROMANIA

By flushing molten iron with methane, benefits such as increased fluidity, improved mechanical properties and reduced cracking tendencies result. It's theorized that CH_4 is dissociated, depositing carbon as soot and liberating nascent hydrogen. Hydrogen bubbles flush the metal while soot nucleates spheroidal graphite.

POLAND

If translation of foreign foundry technical terms into their correct English counterpart has been difficult, your problems may be solved by a new 6-language Vocabulary of Foundry Practice dictionary. Practically every metalcasting technical term is listed in English in a master index with code number reference. Turning to the numerical reference, the proper terminology is listed in six languages—English, German, French, Russian, Polish, and Czech. A master index is also provided for each of the other 5 languages with code number references listed.

With so much foreign language technology appearing in print this dictionary will help clarify foundry terms that are so often improperly translated. By publishing this book, Slownik Terminologii Odlewnictwa, the Poles have made a significant contribution to international metalcasting understanding.

RUSSIA

The All-Union Conference on ductile iron problems revealed the advanced state of this particular facet of Soviet foundry technology. A potpourri of meeting highlights include such interesting comments as: 86 per cent of all ductile iron castings produced are rolling mill rolls . . . nodular graphite is nucleated by bubbles of magnesium vapor . . . ductile iron crankshafts showed no wear after 70,000 kilometers (43,400 miles) road service . . . iron is magnesium treated in autoclaves at 5.5 atmospheres pressure and temperatures of 1450-1500 C (2640-2730 F) . . . ductile iron is being made by tapping onto magnesium fluoride or chloride and calcium silicide placed on ladle bottom . . . black spots are eliminated in crankshafts by adding 0.45-0.50 per cent cryolite along with the magnesium . . . fluidized bed is used for rapid cooling of ductile castings. As in the U. S., ductile iron applications are growing rapidly and new technology is improving its competitive status.

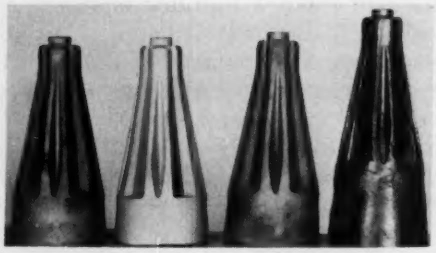
The Bolshevick Engineering Works at Kiev has developed an exothermic riser sleeve mixture for steel that costs only one-fourth that of the conventional aluminum—iron oxide types. The new mix contains 80 per cent charcoal, 12 per cent sawdust, 5 per cent bentonite and 2-3 per cent sulphite lye. Sleeves are dried 4 to 5 hours at 140-150 C (284-302 F) before using. Steel casting yields of 80 per cent are claimed. With many foundrymen objecting to the expense of certain exothermics this new economy mix should stimulate more extensive use. Improved yield and more efficient risers lead to vital cost reduction.

The Likhachev Automobile Works in Moscow is enthused with their success in casting iron, steel, and non ferrous parts in water cooled

thin walled, chill molds. Mold wall thicknesses do not exceed 5 mm (0.197 inches). Molds have held up for 5-15,000 castings at casting rates of three to four parts a minute. Castings weigh from 0.5 to 70 kg (1.1 to 154 pounds). Compared with sand casting, chill mold casting is 20 times faster, requires only $1/10$ the labor, and raises properties significantly. The improved quality and efficiency of this operation makes it well suited to mass production of automotive parts.

After 14 months of successful operation in the USSR a coke-gas cupola has proven dependable when using 10 per cent coke and 300 cubic meters per hour natural gas at NTP. Metal temperature at spout is 1430 C (2600 F). By raising gas input to 450-500 cubic meters per hour, output can be raised 20-25 per cent. Special design features were incorporated into the cupola. Interests run high in the development because it promises better quality control in iron making.

UNITED STATES



Watertown Arsenal announces invention of a new molding process involving one binder and any common refractory such as silica or zircon. Molds and cores made by this process do not evolve gas when poured, are stable during air and vacuum pouring, do not react at all with most casting alloys (including uranium) and can be mass produced in same fashion as resin bonded shell molds. Pictured here are the first four castings of widely differing metals made in this new mold material. All details will be presented in MODERN CASTINGS in a later issue. Left to right: FS 1020 steel, 356 aluminum, 88-10-2 bin.

INDIA

The Institute of Indian Foundrymen held their annual meeting in Bombay for the first time. Institute President, Dr. Nijhawan summed up the tremendous progress of India's metalcasting industry and future plans. By 1963 the National Foundry and Forge Training Centre at Ranchi will provide higher technical education and training in the foundry field.

India's Third Five Year Plan calls for expenditures of $23,625,000,000 to improve her agricultural, industrial, and human resources. About eight pig iron production plants of 1000 ton per annum capacity each will be placed in operation. Ferrous castings production totaled about 0.86 million tons in 1960. The Plan calls for raising this capacity by 1,350,000 tons. Booklet "India's Economic Development" details this ambitious program which should provide profitable export market for U. S. Industries. Write MODERN CASTINGS for complimentary copy.

JAPAN

Malleable iron foundrymen around-the-world are working on ways of extending the section size parameters of their products. The Research Institute for Iron, Steel, and Other Metals has developed a new metallurgy family of malleable irons that is readily cast white yet can be annealed with ease. It digresses from normal analysis by being a low manganese-high silicon type. Sum of carbon and silicon reaches 4.0 to 5.0 per cent while manganese/sulphur ratio can range from 0.70 to 4.66. Current practices usually set a 1.7 lower limit on this ratio. Success in the 0.70 to 1.7 ratio area has been attributed to the combining metallurgical forces of low manganese, high sulfur, and high silicon.

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For more information, write Manager, Foundry Coke and Pig Iron Sales.

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CONSHOHOCKEN, PA.

AMERICAN IRONMASTERS FOR MORE THAN 135 YEARS

Circle No. 128, Pages 133-134

From and For the Reader . . .

QUALIFIES MULLING EFFECT

Authors G. J. Vingas and A. H. Zrimsek have done a commendable job on their paper "Systematic Approach to Sand Design and Control, Progress Report 3—The Mulling Effect," page 95 of February MODERN CASTINGS.

Several years ago a sub-committee of the AFS Sand Division undertook the study of mulling techniques. This effort bogged down in disagreement on so many details that the effort was abandoned. Any attempt to establish fundamental principles on mulling techniques and their effects on sand properties and behavior is quite complicated.

Molding sands that are relatively low in moisture content are the most important if casting quality is considered. Most accurate dimensional tolerances and maximum freedom from sand defects on castings are achieved with molding sand that is low in moisture, high in clay, and rammed uniformly hard. The authors have pointed out that this type of sand requires the most attention to mulling efficiency.

The green properties depicted in the paper were all obtained on freshly mulled sand. This information is pertinent only when new sand mixes are used. Sand properties may change drastically with aging. Green compressive strength, for example, may be only 5 psi after inefficient mulling and may rise to 15 psi after tempering for 24 hours protected from moisture loss.

In a typical iron foundry system, sand mulling is far less critical if the sand-clay combination is exposed continuously to water, without completely drying out, than in a steel foundry where facing sand is compounded of dry, new or reclaimed sand, and dry clay with moisture mulled in and the sand used immediately.

The amount of mulling required to develop optimum properties from the clay and water added is tremendously affected by the moisture content of the sand-clay mixture for several hours prior to mulling. It is here-by suggested that tests made on freshly mulled new, dry sand and clay mixture be compared with test results on the same mixtures after several hours. If this tempering time is possible under production conditions, the effects of mulling time and efficiency tend to be minimized.

Any interpretation of the results cited in this paper should be modified by consideration of individual foundry conditions and further test be made simulating the time-moisture conditions prevailing in the individual foundry.

VICTOR ROWELL
Archer-Daniels-Midland Co.
Cleveland

RAILROAD CASTING USE

In a survey of the railroad industry, page 31, July MODERN CASTINGS, railroad equipment manufacturers were asked what improvements were desired in castings. In general our observations are in agreement. Specifically, we would like to see dimensional tolerances held to a minimum to reduce machining. Also an improvement in finish and reduction or elimination of porosity and inclusions.

We prefer castings over fabrications to reduce the cost of complicated assemblies and maintain dimensional stability after machining. Three types of castings are bought for railroad equipment. Carbon and high tensile alloy steel castings made by the sand casting process are used for pressure and non-pressure applications. Stainless steel castings made by the centrifugal process are used

TENZALOY

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3. Remarkable dimensional stability
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5. Excellent corrosion resistance
6. Permanent, silvery-white finish

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Write for your copy of Bulletin 103R5 to: Federated Metals Division, American Smelting and Refining Company, 120 Broadway, New York 5, N. Y.

ASARCO

Circle No. 131, Pages 133-134

for pressure applications. Malleable castings are used for both pressure and non-pressure applications.

THOMAS E. FOOTE
Union Tank Car Co.
Chicago

MAGNESIUM PRODUCTION

Thank you for the excellent presentation in the June issue on magnesium. One of your subheads states that "The Armed Forces still require the output of most magnesium foundries. The emphasis is in aerospace vehicles."

Actually the armed forces are taking only a part of the business. Magnesium foundries are ready, willing, and able to take on almost an unlimited volume at the present time.

JERRY SINGLETON
Executive Secretary
The Magnesium Association
New York

REQUEST FOR REPRINT

We would appreciate permission for republication of "Clay Test Proves New Control Tool" published in the April issue of MODERN CASTINGS.

Our office in Pretoria reports that the *South African Engineer,* a technical magazine published in Johannesburg, has requested permission to reprint the article.

GARRETT K. SIAS
Chief, News and Features Branch
Press and Publications Service
United States Information Agency
Washington, D. C.

Editor's Note: We are pleased to grant permission for the reprinting of the article, and are always ready to cooperate in spreading the new technology for profit.

F. E. F. AUTHORS

After checking MODERN CASTINGS for the past 12 issues I find that 14 authors were Foundry Education Foundation students during their undergraduate or graduate days. All appeared as authors or co-authors for one or more articles in MODERN CASTINGS.

These former F.E.F. students are F. L. Arnold, R. V. Barone, G. A. Colligan, M. C. Flemings, Jack Kevarian, Henry Kunsmann, C. L. Langenburg, Carl Loper, E. J. Poirier, William Shaw, M. L. Slawsky, Stuart Uram, S. E. Wolosin, and A. H. Zrimsek.

E. J. WALSH
Executive Director
Foundry Educational Foundation
Cleveland

CORE OIL SELECTION CHART*

CORE BAKING PROBLEM		CORE OILS RECOMMENDED - listed in order of preference							
		BLACK OILS				AMBER OILS***			SPECIALTY OILS
SECTION SIZE CORE (inches)	CURING CONDITIONS** AND BAKING TIME (420-450°F BAKING TEMP.)	1	2	3	4	1	2	3	
1 and under	FAST (less than 30 min.)	750	731	730	720	Sup. L.	RO503	Cont.	Lin-O-Plast Impeller cores D-Process #4 Impeller cores where lower green strength needed
	MEDIUM (30-45 min.)	731	730	720	710	RO503	Cont.	#3	
	SLOW (Over 45 min.)	730	720	710	---	Cont.	#3	Li. Ro.	
1 to 3	FAST (30-45 min.)	I #6	I B-2	I C-2	I C-3	I #1	I #4	---	Archer #1 Boiler section cores (complex) and radiator cores 720-Boiler section cores (regular)
	MEDIUM (45-60 min.)	I B-2	I C-2	I C-3	750	Sup. L.	RO503	Cont.	
	SLOW (Over 60 min.)	731	730	720	710	RO503	Cont.	#3	
3 to 6	FAST (45-90 min.)	I #6	I B-2	I C-2	I C-3	I #1	I #4	---	
	MEDIUM (90-120 min.)	I B-2	I C-2	I C-3	750	Sup. L.	RO503	Cont.	
	SLOW (Over 120 min.)	750	731	730	720	RO503	Cont.	#3	
6 and over	FAST (90-150 min.)	I #6	I B-2	I C-2	I C-3	I #1	I #4	---	704-For poor quality sands high in clay content and poor grain distribution
	MEDIUM (150-300 min.)	750	731	730	710	RO503	Cont.	#3	
	SLOW (Over 300 min.)	730	720	710	---	Cont.	#3	Li. Ro.	

*Core Oils are recommended in broad generalizations. Specific core problems within a shop may require deviations from the recommended oil to meet specific needs.

**Oven Conditions Assumed
1. Temperature is controlled and even
2. Load is optimum or under
3. Air supply is plentiful

***Amber core oils are not in all cases equivalent in strength or speed to the black oil recommended for the same general condition. This is particularly true of Inductol #1 and #4 which are the fastest baking oils available. The main criterion upon which oils were selected was baking speed

Legend:
All oils are Linoil Series unless otherwise identified as follows:
I - Inductol
Sup. L. - Super Linoil
Cont. - Continental
Li. Ro. - Liquid Rosin

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Help Promote Metalcasting in School Programs

by R. E. BETTERLEY

Last month we discussed the role of cast metals in industrial arts programs (see MODERN CASTINGS, July, page 28). Something should now be said regarding assistance to these school programs by local AFS Chapters and foundry personnel.

To improve and promote this area of training, the *scope* and *objectives*, as previously discussed, should be kept in mind. Although these programs are predominately taught in laboratories, lecture facilities are also utilized to present *related, technical,* and *occupational guidance* information. Metalworking is a *basic* subject area of these programs.

These courses, although they may begin in the elementary grades, are chiefly centered in the *junior* and *senior* high schools. At this level foundry is advisably taught as an "area" of a "general-metal" shop. In such schools as technical high schools, vocational schools and technical institutes it is, however, recommended that cast metals be taught in a "unit" laboratory; i.e. teaching foundry only.

Local AFS Chapter personnel and the cast metals industry *should* be interested in fostering these programs. Why? *First,* foundry management should be interested from a personnel point of view. Many students, because of varying circumstances, terminate their formal education at the end of high school or before. Practical cast metals training, even though limited at this level, can be conducive to the success of students when employed by the foundry industry. The cast metals industry can strengthen this pre-employment background by up-grading their local school programs. *Secondly,* it should never be forgotten that *all* students, college-bound or not, are potential *castings buyers.* Consumers knowledge, alone, is a prime objective of *any* industrial arts program.

To introduce cast metals instruction into industrial arts programs, we should keep *one* basic obstacle in mind: *fear.* This fear can stem from a lack of technical knowledge, skill and training on the part of the teacher. Important, too, it can be a fear of student safety through misunderstanding by parents, teachers and school administrators. Local foundrymen can provide vital assistance in correcting the conditions creating these fears.

Additional support for these programs can be accomplished as follows:

1. Discuss foundry teaching and safety with teachers and school officials.
2. Help provide materials and equipment. Judgment should, however, be exercised to provide used equipment suitable for school use.
3. Organize plant visitations for teachers and students.
4. Offer services for school talks and demonstrations.
5. Keep teachers informed of new foundry developments.
6. Have "Education Night" chapter meetings.
7. Encourage teacher participation in chapter activities.
8. Conduct Instructors' Seminars to improve teaching.
   (Note: This has been successfully done by several A.F.S. chapters)
9. Assist schools in Career Carnival exhibits.
10. Provide speakers for parent-teacher groups and civic organizations.

Schools not having foundry facilities can *still* provide some instruction through movies, books, lectures, literature and demonstrations. A small practical Foundry Teaching Aid Kit is now available for molding demonstrations not requiring a cast metals laboratory. Utilizing alloys which melt under 160°F., the demonstration can be *safely* performed in any classroom. This kit will be available on a loan basis from national headquarters in the near future, or it can be secured from Cerro Sales Corp., 300 Park Ave., New York City.

Local foundrymen should survey their public high schools regarding cast metals instruction in industrial arts programs. By *tactfully* working with parents, teachers and school administrators, they can aid their community and *themselves.*

Metal & Alloy Division
of Silver Creek
Precision Corp. uses . . .

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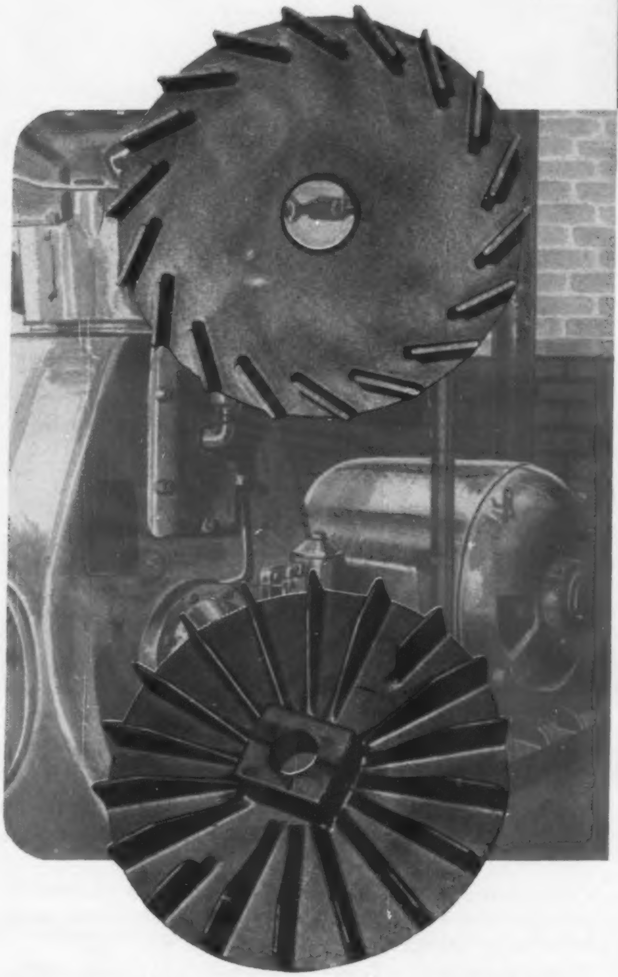

METAL & ALLOY DIVISION of Silver Creek Precision Corp. uses PETRO BOND waterless molding sands for intricate bronze and aluminum castings. The silica-bronze electric motor cooling parts shown here were cast in PETRO BOND sands at METAL & ALLOY's Buffalo, New York, foundry. Because of the smooth surfaces and excellent pattern reproduction obtained, METAL & ALLOY has drastically reduced the cost of machining the cooling blades.

PETRO BOND sands are bonded without water . . . permitting the use of fine-grain sands because of less gas. Molds shake out fast, sand doesn't stick to castings.

PETRO BOND produces precision castings with conventional foundry equipment. Castings are sounder . . . with closer tolerances and less porosity . . . there are fewer rejects.

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Hot Men Break Down in Hot Surroundings

by Herbert J. Weber

Man is a machine that does work. Like any other piece of machinery, he generates heat when he works. We know we must cool an automobile engine when it does work. Likewise man, the machine, must be cooled when he works or he will become inefficient or break down entirely.

Body heat balance is necessary for health and comfort. Under normal conditions, the heat produced by the body is offset by the heat lost to the surroundings without active sweating.

But in environments hotter than skin temperature (92 F. in the winter and 95 F. in the summer) man will become hot unless he can get rid of his own body heat and that reaching him by hot air and radiation from hot objects. He must do this by evaporating sweat.

If he is unable to do it, a substantial increase in body strain or even prostration will result.

It has been observed that men doing work in hot surroundings are apt to have more accidents than when working in comfortable temperatures.

Studies at Ohio State University have shown the upper limits of temperature to which industrial workers can be exposed. By graphing wet-bulb and dry-bulb temperatures, it is possible to determine an unsafe heat exposure index. Wet-bulb temperature is the result of a combination of air temperature and relative humidity. The greater the relative humidity, the less heat a man can stand. The reading on an ordinary thermometer only is not an accurate measure of heat exposure.

For example, a combination of wet and dry-bulb temperatures of 85 degrees, or a wet-bulb reading of 84 degrees and a dry-bulb temperature of 95 degrees both indicate an unsafe exposure.

Then the question of the effectiveness of salt tablets frequently arises. Some authorities believe that we get enough salt in our daily diet to replace the salt lost through perspiration. On the other hand, cases have been reported where workers had an insatiated thirst not satisfied by any amount of drinking water until the water intake was supplemented with salt.

Thirst is not necessarily a reliable index of water needs. In extreme heat exposures, men may actually need more water than their thirst indicates. Therefore they should be encouraged to drink water even though they do not feel thirsty.

Here are some things that help reduce the heat stress:

1. Interposing reflective aluminum shields or screens between the hot source and the man will often cause a dramatic reduction in his heat load.
2. Adequate rates of air change around a hot process will help somewhat. But don't expect anything dramatic.
3. Crane cabs, shop foremen's offices and panel-control areas may be supplied with mechanical refrigeration.
4. Man cooler fans will evaporate moisture from the body causing a cooling effect. However there is a point of diminishing returns here. Man coolers help but are not a complete answer. (See Modern Castings, July, 1960, p. 19.)
5. Air-conditioned lunch rooms give men respite and afford an opportunity for the body temperature to return to normal.
6. In one plant, that I know of, the shakeout crew had to be divided into two sections which spelled each other off, in order to avoid heat prostration.
7. Often a work break will result in greater production since there is a limit to human endurance of heat. As a man approaches his limit, his efficiency falls off.
8. Men should wear the usual work clothing rather than be stripped to the waist because the clothing protects against hot air and yet permits evaporation of sweat.

Remember, if men get too hot, their efficiency falls off and the accident potential increases and remember also that even machinery fails when it runs too hot.

So when cooling your machines, don't forget your men!

METALGRAMS

UNION CARBIDE METALS

. . . news of "Electromet" ferroalloys and metals

AUGUST 1961

GE IMPROVES MACHINABILITY WITH "SMZ" ALLOY -- All 30,000 and 40,000 psi gray iron made at General Electric's newly modernized foundry in Elmira, N. Y. is inoculated with 2 lbs. of "SMZ" alloy per ton. Why? These irons tend to chill in thin sections, making machining difficult. By adding "SMZ" alloy, GE can pour ½-in. thick sections or less that can be easily machined. In a typical test, GE's chill blocks showed a chill of 22/64-in. for uninoculated iron. The iron inoculated with "SMZ" alloy had only 14/64-in. chill.

* * *

ALLOYS BOOST GRAY IRON PROPERTIES -- GE also gets special properties by adding alloys in the ladle. Chromium and molybdenum improve wear resistance. Nickel and silicon increase electrical resistivity. Chromium and silicon give a close grain structure in heavy sections, which gives a good surface finish after machining. Chromium and nickel retard growth at high temperatures. For more information on GE's use of these ladle additions, including "SMZ" alloy, write for the article, "More Efficient Cupola Melting," in the Summer 1961 issue of UNION CARBIDE METALS REVIEW.

For more information circle 152 on page 133

* * *

MAKING MORE PERFECT METALS -- Vacuum melting is meeting the higher property requirements of space and atomic uses. Vacuum-melted steels, superalloys, and ultra-pure metals have better properties than their air-melted counterparts. Union Carbide Metals supplies a complete range of ferroalloys and metals for steels and superalloys melted in a vacuum. UCM also offers high-purity, vacuum-melted ingots of columbium, tantalum and vanadium metal. For more information, call your Union Carbide Metals representative today. Also, ask for the article, "Making More Perfect Metals," in the Summer 1961 issue of UNION CARBIDE METALS REVIEW.

For more information circle 153 on page 133

* * *

THIS 'N' THAT -- Magnesium-ferrosilicon is the lowest-cost alloy for making ductile iron. It also promotes high as-cast ductility. Write for F-20,069 and F-20,120 or circle 154 on page 133. . . . Money-saving advantages of "EM" briquets include no weighing, higher recoveries, easy identification, closer control of casting chemistry, easier handling, and savings in raw materials. Briquets are added to gray iron in the cupola. Write for F-20,066 or circle 155 on page 133. . . . "Simplex" ferrochrome features rapid solubility, low price and extremely low carbon content -- characteristics needed for chromium additions made during reduction or finishing periods of a stainless steel heat. Write for F-20,118 or circle 156 on page 133.

* * *

UNION CARBIDE METALS COMPANY, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. In Canada: Union Carbide Canada Ltd., Toronto.

An Eastern Foundry Conveys and Cools 120 Tons per Hour of Sand with Simplicity "VS" Conveyor

The Simplicity model "VS" conveyor shown moves hot sand from two shakeouts, up a three degree incline, to an elevator at an average rate of 80 tons, with a peak load of one hundred twenty tons per hour. As the sand moves along the conveyor deck, water is added and plows turn the sand thus reducing the sand temperature one hundred degrees. The sand is discharged from the conveyor into the elevator boot over a permanent magnet which removes all of the metal particles.

Simplicity conveyors have proved efficient for transferring materials such as sand and castings, from one point to another. Feed points can be positioned along the length of the conveyor, and materials transferred to a common discharge point.

"VS" conveyors are available in widths from 12" to 36" and in lengths from 10' to 60' with one drive assembly. At customer request, these conveyors can be equipped with liners, covers, or can be built in two surface units.

Write for catalog C-1 which describes the various models of Simplicity Conveyors.

Simplicity TRADE MARK REGISTERED

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FOR CANADA: Simplicity Materials Handling Limited, Guelph, Ontario.
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Circle No. 137, Pages 133-134

On the Other Hand— Women have Proven Ability

by H. F. Dietrich

After the article on "Foundry Women," I have been accused of discrimination against the most important segment of our population. Nothing could be further from the truth, and I would be remiss if I didn't point out the *good* qualities of female foundry employees.

Women are indeed an important factor in our society. Who owns most of the country's stock? Who spends most of the country's money? Who keeps a man alive and working—whether he feels like it, or not? Who rocks the cradle of the world? And finally, who dreamed up the idea of putting curtains on a hearse? You guessed it. *Women!* They guide a man through life, and keep him from going astray even in death.

It would be telling half truths to enumerate only the disadvantages of the employment of women in the foundry.

Women are natural-born salesmen. The most illogical argument for buying a product takes on a degree of logic when presented in soprano. During the war, when castings were controlled by government allocation, I met a female expediter of production who could have charmed castings out of an ordnance plant. It would have been hard to turn down her orders for castings if I hadn't had the power of the Federal Government—and the prospect of room and board at Alcatraz—behind me. This was in spite of a built-in sales resistance to this hard-sell routine.

Women are well suited to industrial chemical analysis. While a man might be inclined to do a little pencil titration on an off-color result, a woman will conclude that someone else made the mistake. Because of this attitude, she will record what she finds regardless of the improbability of that report.

The female psychological constitution is better equipped to handle monotonous, repetitious work. Women can make pin-cores on a core-blower day after day without harmful effect. That job would drive most men stir-crazy within a week.

A woman has a system for handling such situations. She gets her hands started on the job and follows them until they are trained to do the work. Then she shifts gears allowing the hands to free-wheel until coffee break. In the meantime she can figuratively sharpen her claws on a convenient friend, brag about her house apes, or dream that she is a TV queen. With this built in relief mechanism, there is no strain.

The feminine ability to find mistakes made by others makes women excellent casting inspectors. Not knowing—or caring—about the ultimate use of the casting, they will follow to the letter the instructions on defective throwouts. They can be vernier tuned to any degree of acceptability.

How many men can reach over their shoulder with their right hand, reach around their back with the left hand, and touch the fingers of both hands between their shoulder blades?

Most women can do this. It is such dexterity that makes women better workers on small parts than their male counterparts.

Finally, we have had female foundry managers ever since the industrial revolution. By one means, or another, they acquire control of the foundry operation and make it run. Although they are willing to seek advice freely, they feel no obligation to take that advice. Who can say that they are not as successful in handling the job as would be a man in the same situation?

Ed. Note: Anyone have a rebuttal?

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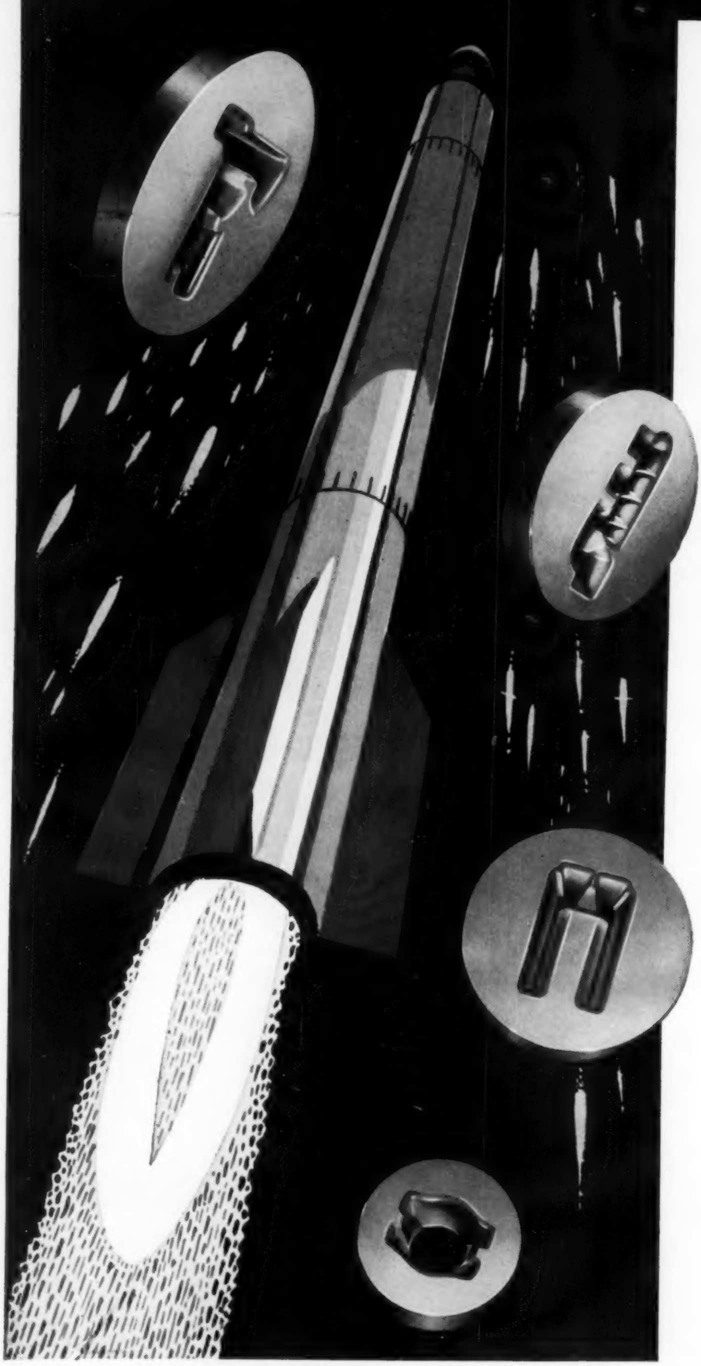

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Circle No. 140, Pages 133-134

Carbon Sand Provides On-the-Job Economy

A 1961 New Technology Breakthrough has already found acceptance on the production level at the Manistee Iron Works Division. It saves money, time, labor, and has proven very versatile. See details in July Modern Castings, *New Technology section, page 88.*

Completed casting of a machine tool gear housing. Carbon sand was used in facing each of several cores all set in a cold cure process.

By Jack Elliott
Foundry Superintendent, Manistee Iron Works Div.

Cost savings from initial purchasing through reductions in cleaning room time have taken carbon sand out of the experimental stage and into production practice at the Manistee Iron Works Division.

Essentially, carbon sand—a calcined fluid coke—has been used as a replacement for zircon sand. This new non-silica molding medium is best described as a "round-grain carbon sand." It consists of a solid, hard, round-grain carbon particles. The grain surface is reasonably smooth and unbroken since it is a pulverized material.

Savings of $5 per ton have been realized over zircon sand at Manistee. Because of its low apparent density, approximately 9 lb per gallon, it is giving about 2-1/2 times the useful volume of zircon sand.

Our foundry produces a wide range of castings varying from 300 lb to seven tons. Most of the work is in gray iron, classes 30, 40, and 50, with a smaller production in 88-10-2 bronze and 85-5-5-5 brass. We are also investigating its use as a chilling element on aluminum castings. Principal castings are for machine tools, pump parts, miscellaneous engineering castings, jigs, fixtures, and some dies.

Carbon sand is used for spot fac-

1. Workman places carbon sand on pattern for a core used in casting the machine tool gear housing. In cold cure process carbon sand faces core and bank sand backs it up.

2. This is the only "ramming" necessary in packing the carbon sand. The entire surface of the core box is covered, generally to a half-inch depth.

4. Drawing the pattern from a core composed of carbon sand. Facing material is the dark area along the edge of the core, and the remainder is the silica sand. Cold cures are made with self-setting oil, phosphoric acid and boric acid powder mulled into the carbon sand.

3. Conventional silica sand is used as a backup for the carbon sand. Note the use of a portable hopper for carrying the bank sand.

ing on cold cure cores, and baked cores. A green sand mixture is also being used primarily on large, heavy molds including gray iron and brass and bronze. It is employed primarily on large flat copes and top faces of drag pockets to insure against scabbing and buckling. Slinger sand is used for the side walls and back-up; a large per cent of these molds are dried by torch or charcoal firing.

The molding mixture for spot facing consists of 1000 lb of carbon sand, 50 lb bentonite, 100 lb fire clay, and 7-1/2 gal water.

Fits Binders and Processes

All commonly used core binders can be employed with carbon sand. Round-grain carbon sand lends itself to use with most conventional foundry equipment and to the relatively new processes such as shell molding, CO_2 process, air-setting, no-bake, and hot-box.

At Manistee cold cure cores are made with carbon sand, self-setting oil, phosphoric acid, and boric acid powder mulled into the sand. Cores are faced to a depth of 1/4 to 1-1/2 in. and backed up with conventional silica sand. Packing the sand is relatively simple. The carbon sand is applied, making certain the entire surface of the core box is covered. Generally the depth is 1/2 in. Hands and fingers can be used for this packing. Ramming is not necessary. Backing sand is dumped into the core box and packed first manually and fingers. If the core box is large, tamping is done by treading. This is the only ramming needed.

Baked cores are small, produced on the bench, and packed by using a rammer. The mixture for baked cores consists of 25 per cent bank sand, 25 per cent lake sand, and 50 per cent carbon sand, cereal binder, water and core oil. No attempt is made to recover the carbon sand after shakeout; it becomes a part of the sand system used for back-up.

Carbon sand allows easy drawing from the pattern and provides an extremely clean surface. The excellent finish is achieved without painting or washing cores. This saves considerable and eliminates brush or spray marks.

These savings are illustrated in the case of making cores for a machine tool housing. It takes approximately three hours to ram the cores and 40 minutes to draw. Core washing, with all of the fins involved, would take up to four hours.

Carbon sand's stability and low expansion coefficient, approximately 1/8 that of silica sand, also provides cost savings. Other advantages are its inert nature and resistance to wetting by molten metal. These characteristics have meant an important reduction in expansion defects. Virtually all scabbing, buckling, and rat-tailing have been eliminated. Grinding time has been cut by 20 per cent.

Carbon sand is a 4-sieve material, reasonably free from fines. The average grain fineness of 70 allows versatility in both cores and molds for the various metals.

A typical screen analysis:

U.S. Sieve No.	% Retained On
20	1.2
30	0.6
40	1.9
50	9.6
70	25.9
100	32.3
140	19.6
200	7.4
270	1.1
Pan	0.3
	100.0

AFS Fineness No. 73.3

To date, the use of carbon sand at Manistee has provided a more workable medium than zircon in a wide range of applications, especially in the core room. It has further offered important time and labor savings which help the foundry in its goal of producing better castings at a lower cost.

Die Cast Zinc Meets Competitive Demands

Zinc die casters look for 10 to 20 per cent growth in demand over the next five year period.

New technology, educational promotion, and imaginative sales engineering are making an across-the-board drive on industrial markets.

More cars per year and more zinc per car may result in an excess of the 400,000-ton peak of 1955.

Automation and mechanization have upped productivity as much as 50 per cent. New developments are lowering die costs, raising casting properties, and improving plating performance.

By Jack H. Schaum

Stimulated by the challenge of change, zinc die casters are penetrating new markets and reaching for a diversified group of new customers. As a result of the drive to broaden this base, zinc consumption for non-automotive die cast users has reached its highest level in history.

Zinc die casters polled by Modern Castings were almost unanimously confident about growing demands for their output over the next five years.

Predictions ranged from two per cent to as high as 20 per cent for gains in zinc consumption over the period. One metalcaster looks for a 10 to 15 per cent increase in 1961—hastening to add that it won't come unless plants increase their efficiencies in production and handling. Another executive indicated the available market for zinc die castings could increase as much as 50 per cent in non-automotive fields.

The automotive market still commands the largest consumption. The die casters are making an all-out effort to increase this 200,000 tons-a-year business.

Their hopes are pinned on a revitalized new car market during the next five to 10 years. E. C. Quinn of Chrysler Corp. has predicted that new car sales will rise to seven million by 1965 and reach eight million by 1970. If present zinc composition patterns continue, automotive consumption could rise 17 per cent during the period.

This increased use of zinc die castings, in the opinion of C. R. Maxon, New Jersey Zinc Co., is not "automatically" assured by population growth. Tough competition from aluminum die castings and plastics will make this growth an uphill struggle all the way.

In the drive to promote new applications, die casters have exercised imagination to capture new markets and recapture lost areas. the metalcasters had to come up with ideas to convince the automotive builders that there were more parts for zinc.

Typical applications on the 1961 models include:

- grill components
- headlight housings
- rear window frames
- instrument cluster assembly
- rear deck lid extension trim
- taillight housings
- bezels
- side moldings
- door frames
- window assemblies
- window crank handles
- rear view mirror parts
- mounting bases
- doors
- hardware
- carburetors
- ventilating window frames
- door handles
- ornaments
- glove compartment

New and improved plating systems have started the preference pendulum swinging toward use of more zinc in decorative applications. Many stainless steel and aluminum car parts are being replaced.

Research by the Perfect Circle Co. produced a new market for six die castings. The product permits car speeds to be held constant at any pre-set speed—ideal for today's turnpike driving. Ohio Die Casting Corp. casts the overall housing, a mating cover, a drive adapter assembly, a speed selector assembly body, a motion transfer member, and panel hardware. Zinc die castings were selected because of the intricate design and need for thin walls, close dimensional tolerances, easy machinability, and minimum draft (0.004 inches in 1-1/2 inch).

Strong efforts continue in developing new markets which will help emancipate zinc die casting from their heavy dependence on the automotive market. For instance, a power lawn mower builder is making a pulley and bevel gear as a

single zinc die casting with a powdered bronze, self lubricating bearing insert.

This month's cover illustrates a two-piece construction used in place of six for the frame and gear housing cover and drive gear of a modern egg beater produced by Turner & Seymour Mfg. Co. in Torrington, Conn.

Another company has recently converted a cast iron electric motor bearing lock ring to die cast zinc. Advantage is taken of zinc's corrosion resistance and ability to be accurately die cast. As a result of conversion, four machining operations are eliminated. Annual production of this item runs more than 100,000 units. The same company is also die casting a motor fan in zinc.

Best for Close Tolerance

In a great many instances chrome plated zinc castings have taken the place of fabricated parts such as extrusions used for decorative purposes on stoves, dishwashers, washing machines and other appliances. The fact that zinc die castings are more suitable for close tolerances than any other die cast alloy or as a matter of fact any other method of basic manufacturing has assured zinc die casting a place in the almost unlimited field of computers and business machines. Another and more prosaic field for zinc die casting is the field of modern lighting fixtures, for outdoor or indoor use these areas, in the opinion of Paul Bock, Los Angeles Die Casting Co., represent today's most important new applications.

The whole competitive field of stampings provide a reservoir of market opportunities for new applications. Because of zinc's low melting point and rigidity it can be die cast as thin as sheet metal and yet have the desirable rigidity of a cast product. Tedious assemblies of separate stampings can be designed into a one-piece die casting that is smaller, more compact, and better aligned. With modern die temperature controls large castings can be made with walls only 0.040 inches thick.

A manufacturer of office and residential lighting equipment is now saving 30 per cent in production costs by switching from steel stamping to die cast zinc. Ability to attractively plate his product has added further incentive to the change. As a result zinc die castings are being used for 10 different basic frames, 10 types of round and rectangular canopies, four kinds of bullet cones, three types of swivel assemblies, and hundreds of brackets and fittings.

Offers Smoother Finish

Sand cast parts are often converted to die casting to achieve smoother finish, less draft, more accurate cored holes, less machining, and surface perfection better suited to plating. Die casting usually benefits from product success —as demand increases, more units are needed and mass production requires the high speed high volume production economies inherent to die casting.

In 1925, about 15,000 tons of zinc die castings were shipped. By 1955 this figure had grown to 400,000 tons.

Such success is a tribute to a profitable combination of an ideal material with a casting method best suited to the mass production needs of broad consumer markets. The biggest stimulus is the automotive industry which purchases 60 to 65 per cent of all die castings sold. Last year a 15 per cent gain

Zinc Die Casting Properties Compared to Aluminum and Magnesium

This table, prepared by the New Jersey Zinc Co., shows the favorable ranking of zinc alloys in mechanical properties, physical constants, casting characteristics, and cost. In die castings consumed, zinc ranks first.

SELECTION FACTOR		ZINC ALLOYS	ALUMINUM ALLOYS	MAGNESIUM ALLOYS
MECHANICAL PROPERTIES	Tensile Strength	1 (strongest)	2	3
	Impact Strength	1 (toughest)	2	3
	Elongation	1 (most ductile)	2	2
	Dimensional Stability	1	1	2
	Resistance to Cold Flow	2	1	1
	Brinell Hardness	1 (hardest)	2	3
PHYSICAL CONSTANTS	Electrical Conductivity	2	1 (highest)	3
	Thermal Conductivity	2	1 (highest)	3
	Melting Point‖	1 (lowest)	2	2
	Weight, per cu. in.	3	2	1 (lightest)
CASTING CHARACTERISTICS	Ease, Speed of Casting	1 (easiest)	2	2
	Maximum Feasible Size	1 (greatest)	2	3
	Complexity of Shape	1 (most complex)	2	3
	Dimensional Accuracy	1 (most accurate)	2	2
	Minimum Section Thickness	1 (thinnest)	2	2
	Surface Smoothness	1 (smoothest)	2	2
COST	Die Cost†	1 (lowest)	2	2
	Production Cost	1 (lowest)	2	2
	Machining Cost	1	2	1
	Finishing Cost‡	1 (lowest)	2	2
	Cost per Piece§	1 (lowest)	2	2
EXTENT OF USE		1 (most used)	2	3

‖ A low melting point is favorable in reducing die cost and upkeep and facilitates casting.
† Dies for casting the low melting point alloys are least expensive and have longest life.
‡ Includes polishing and buffing expense as well as ease of applying all types of commercial finishes, both electrodeposited and organic.
§ Based on die and fuel costs, production speed and machining and finishing costs.

End-Use Distribution of Zinc Die Casting Sales

Totals represent all job shop sales, estimated in pounds, for 1960. Captive use is not included. The figures are from American Die Casting Institute.

Consuming Industry	Pounds Use	Per Cent
Agricultural, mining, construction	4,600,000	1.1%
Automotive	208,600,000	49.8
Other transportation	5,000,000	1.2
Machinery, tools	40,200,000	9.6
Electronics	7,500,000	1.8
Business machines	18,000,000	4.3
Plumbing, heating, hardware	32,650,000	7.8
Optical, recording devices	12,150,000	2.9
Timing devices, clocks	7,950,000	1.9
Home appliances	76,100,000	18.1
Toys, sporting goods, jewelry	5,000,000	1.2
National defense	1,250,000	0.3
TOTALS FOR 1960	**419,000,000**	

was registered. More zinc die castings were used on 1961 full size models.

Leading zinc consumer in the '61 lineup is the Chrysler Imperial 4-door hardtop carrying a total of 172 pounds of die castings. The Oldsmobile dashboard console is the largest interior die casting ever used—56-3/4 inches long, 13 inches wide, 5 inches deep, but only 20 pounds in weight.

Until 1959, the use of zinc die castings in cars showed a steady and healthy growth. The introduction of compacts in 1960, accounting for 27 per cent of domestic retail sales, dropped the average weight of zinc per car. Compacts used less than 40 pounds each compared with 72 for full-sized cars.

This trend has already reversed itself because the public is demanding more luxurious compacts. As the Wall Street Journal stated recently, "Auto makers are finding that economy sells best when it's mixed with a little luxury." This means larger die castings and more casting weight per car.

Ernest W. Horvick of the American Zinc Institute explains: "The time has come for a constructive educational program advising prospective users of the possibilities of zinc die castings and how they can be used to better advantage. The popularity of castings made from zinc alloy stem from such well known factors as their dimensional stability, smooth surface, high-speed and economy in production. What must be expounded to a much greater degree are other significant characteristics.

"Zinc die castings are strong. They are stronger, for example, than gray iron, bronze, brass and aluminum sand castings, and aluminum die castings—particularly in toughness and resistance to shock. They have 10 times the impact strength of gray iron. Due to this and their other properties, it must be made very clear that zinc die castings can excel in all types of service, from decorative parts to vital functional elements that must take severe punishment."

Hitting at the need for more educational promotion efforts, William G. Newton, Newton-New Haven Co., makes this point: "Too many buyers of production components are relatively uninformed as to the capabilities and limitations of the materials which go to make up their components. In this area, the strength and stability of zinc based alloys for die casting should be stressed. The well known Certified Zinc Plan has gone a long way to offer "on grade" analysis of the metal which conforms to known specifications and can therefore be considered reliable."

It is up to die casters to tell product designers that they can save money by eliminating machining. New plating techniques have improved corrosion resistance, and a new market may soon be opened for castings used in food machinery.

Automation has brought a new competitive status to the zinc die casters. No other metal forming process can convert molten metal into usable shapes as fast or with fewer secondary operations. New instrumentation and electronic regulatory devices are guiding the high speed movements of today's modern die casting machines.

At Brown-Lipe-Chapin Division of GMC, castings are automatically ejected so they drop directly into a water quench tank. A conveyor carries casting and gate to trim presses. Die lubrication is also done automatically. This innovation has led to a 50 per cent increase in production.

Other operators are using "mechanical hands" to remove castings from machines. Production speeds are going up. Zinc can be run at rates of 200 to 800 shots per hour—far ahead of aluminum casting speeds. The production speed record is probably held by Injecta in Switzerland—1700 *shots per hour!*

Dies Come Down

A common impasse in the use of die casting process lies in the high initial cost of the die. Long run orders are needed to amortize the die cost with a reasonable levy on each piece. New technological effort is being constantly directed at reducing die production costs and extending service life. The foundry industry itself has come to the rescue with several cast-to-size processes which produce dies that require only minimal machining or polishing. Die sinking has been speeded by spark erosion techniques. And most recently, the nickel-carbonyl process for shaping (Modern Castings August, 1960, page 65).

As die costs go down, manufacturers needing small quantities can consider this method.

Multiple cavity dies help reduce the cost of short runs. Removable sections in a die let different jobs run together off the same sprue system. When enough of any one of the castings is made, a new die segment may be substituted or the

gate blocked off so no metal enters that particular cavity.

Weight conscious auto-builders are realizing that zinc is lighter than you think. Why? Because it can be die cast thinner and over broader areas than any other metal.

Vacuum is a new tool now being applied to extend this capability to new parameters of size and section thinness. Read MODERN CASTINGS, June, p 56 for an up-to-the-minute analysis of commercial values derivable from vacuum.

AFS Joins Research Effort

The American Foundrymen's Society has recently joined with the American Zinc Institute and American Die Casting Institute in a significant research program aimed at investigating the hydrodynamics of liquid metal flowing in die cavities and the design of sprues, gates, and vents to permit production of higher quality castings.

While zinc alloys in use provide excellent performance, engineering requirements are never satisfied. A program was initiated at the New Jersey Zinc Company to develop new and improved zinc die casting alloys especially with respect to strength, creep, castability and plateability.

The zinc-aluminum binary system was selected for investigation, limiting the aluminum content to a range suitable for the hot chamber die casting process. Two improved alloy compositions, zinc–8% aluminum, and zinc–14% aluminum, appear most promising.

The composition, zinc–8% aluminum–0.5% copper with minor alloying additions from the iron group, yields higher hardness with improved physical properties and excellent castability as compared to present alloys. This means a stronger product with a better surface–minimum scrap losses for the die caster. It is also easier to produce more complex shapes with thinner sections.

This alloy should make zinc even more competitive with other metals and plastics. Although it has thus far been tested only in the laboratory, pilot production runs in a commercial die casting facility will begin soon to develop data covering operating limits and plating characteristics.

The development of the double nickle plate has been an important technological advance in the zinc die casting industry. The superb performance of the new plate has strengthened the industry's position in competing for decorative parts business. And considerable inroads are now being made in the plumbing field.

Technology Pays Off

The new plating technology was the direct result of intensive research cooperatively sponsored by the zinc producers, plating suppliers, platers, and automotive industry. All achieved toward a common goal–a better plating process. As result of this combined effort many important plating improvements were made–including duplex nickel, crack-free chromium, and duplex chromium.

The proof of the program's success is the fact that one or more of these new plating systems are specified and used on every automobile produced today. New technology not only saved the zinc die casters from losing a tremendous market but led to more business.

Quality control in every productive step has been a major technical achievement that has generated customer satisfaction. It brings them back with re-orders and new orders emanating from re-designs. The new ADCI production requirement data sheet has contributed materially to the improved buyer-supplier relationships so vital to keeping customers coming back.

Price is still an important factor in the competitive picture. R. E. Robbins, Paramount Die Casting Co., sums up the problem: "Many parts go to aluminum due to the price of zinc being too close to that of aluminum. For many years I personally have felt that there must be a 10 cent spread between the cost of a pound of aluminum die cast alloy and zinc alloy. When this spread is not there, many castings are made more economically in aluminum."

Currently, the spread is greater than the 10 cents, in favor of zinc.

Producers in the field can take heed of a four point program for staying competitive as detailed by Samuel A. Gullo, Chicago White Metal Casting, Inc.:

1. Research for improved metals, better methods and performance.
2. Keep raw materials and labor costs consistent to retain long term consumer confidence.
3. Use more effort in engineering and selling liaison to get prospects to know, to specify, and to be sold on zinc castings.
4. Work for closer industry cooperation to learn the latest in research, production and marketing.

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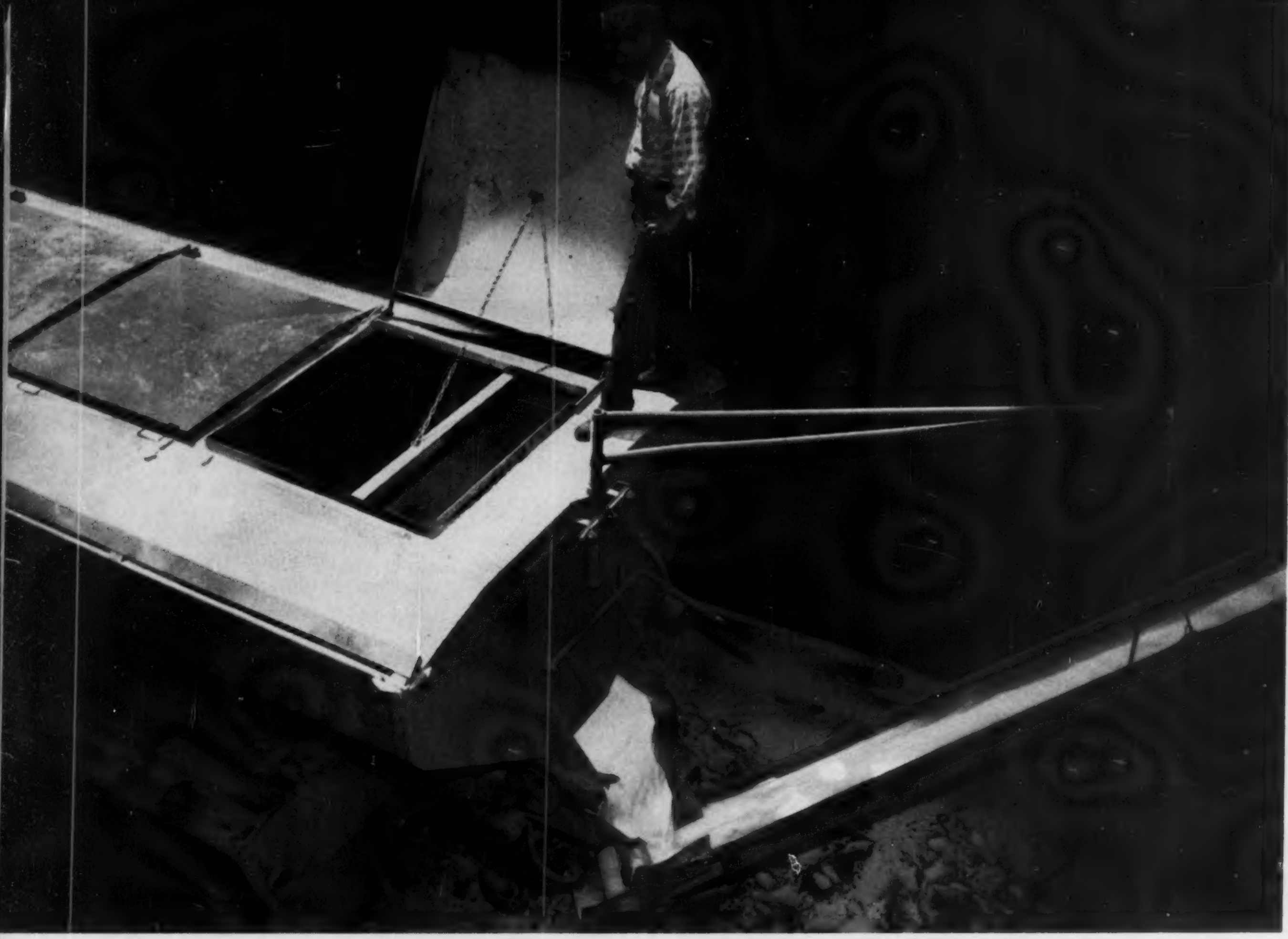


A 17-ton capacity truck delivers silica or other core sands to Kensington Steel on order. The truck is equipped with an airslide hopper and a blower-type conveyor for 45-minute unloading. Because the sand is delivered within 48 hours of a call, there is no need to waste valuable storage space.

Delivering Sand by Truck Brings Multiple Savings

Let the supplier carry the load—sand in this case—and you remove an old problem in materials handling. You also save time and money, they learned at Kensington Steel Co., as well as getting a plus advantage of less segregation on delivery.

By LEO MARINELLI
Kensington Steel Co.

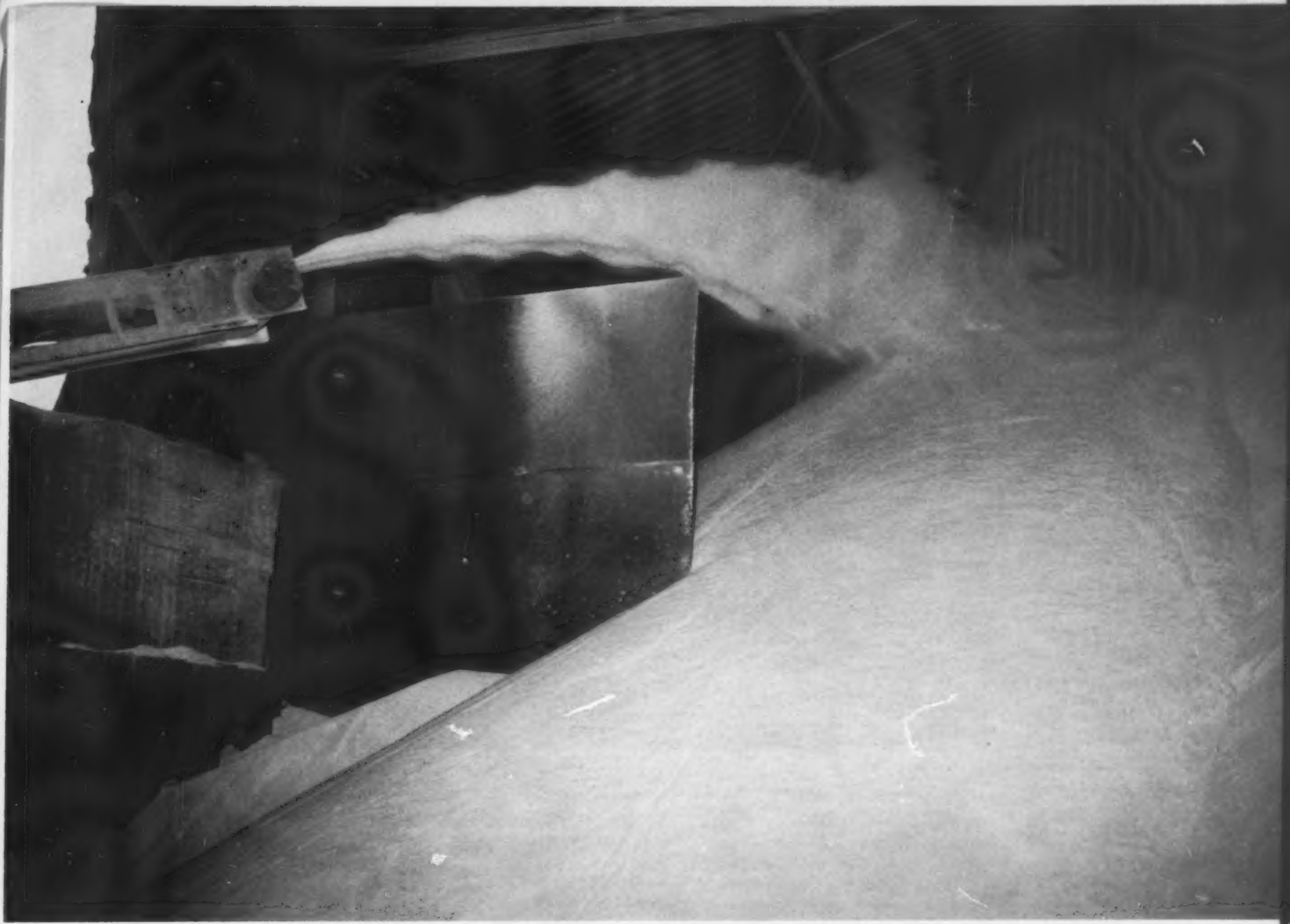
ACCEPTING DELIVERY OF CORE SAND by truck has brought about sharply defined savings in labor, storage and quality control for the Kensington Steel Co. in Chicago.

The economy of trucking core sand from the sand pit to the foundry was given little consideration in the past. Today, in the light of modern-day labor expenses and the increasing cost of inefficient materials handling, it is proving to be an important factor in saving money.

At Kensington today, silica sand is delivered in large (17-ton capacity) trucks equipped with an airslide hopper with a blower attached. The unloading time for the truck is approximately 45 minutes, an immediate saving in time.

A second saving—in time and money—results because the sand is blown into the storage bin, piling up at the *rear* of the bin, not at the front. This eliminates the need for a man with a shovel to tackle tons of sand, moving a mountain from one end of the bin to the other—just to make room.

Because the sand is delivered on order—usually within 48 hours depending upon the weather—there is a saving of valuable space necessary for storage



The blower pictured here sends the core sand to the back of the storage bin in a steady stream. This eliminates the need for a worker to shovel the sand from one end of the bin to another, as it was done in the past. The blower does a good job of remixing the core sand as it stores it.

and more flexibility in inventory control. This is vital to foundries which must change grades of sand as quickly as work changes.

The unloading cost factor has been shifted from the foundry to the supplier. At Kensington, studies made in detail revealed that the railroad car unloading costs ran anywhere from 40 cents to $2 per ton depending upon the proximity to the railroad siding and method of unloading. One of the studies revealed that maintenance on equipment necessary to the operation was costing $500 annually when 2000 tons of sand were consumed. This figure did not include labor, fuel, or depreciation in mechanical automotive unloading.

Today, the economic limit to trucking sand is about 100 miles. Trucks can carry between 17 and 20 tons, but already there are pay loads of 22 tons and the future foresees shipments of 24 tons at one time.

Generally three types of trucks are in use—the conventional dump truck, the conveyor hopper truck, and the newest airslide hopper truck with blower and/or a conveyor attached.

An important plus advantage of the system is that there is less grain segregation when the sand is delivered in trucks. This is due partly to the fact that the sand is usually in transit less than four hours, as compared to days in railroad cars, and partly to the fact that the unloading of the truck with the conveyor and blower provides an excellent remix of the sand. Some segregation occurs when sand is conveyed into the foundry, but the sand as it leaves the truck is almost identical to the shipment ordered.

To back up this study, an analysis was made from a regular truck shipment:

As loaded on Truck		As Unloaded
40 Mesh	2.0%	0.7%
50 Mesh	21.6%	25.8%
70 Mesh	46.4%	43.1%
100 Mesh	24.0%	26.1%
140 Mesh	5.6%	3.7%
200 Mesh	0.6%	0.4%

Management at Kensington is convinced that trucking of silica and other core sands can definitely provide economy for large and small foundries. It removed a long standing problem in materials handling—literally letting the supplier carry the load.

1. An operator simply inserts malleable iron pipe fittings into the machined slots on the perimeter of a revolving turntable. The casting passes over the face of the grinding wheel and moves on to the point where it is ejected from the wheel. This system is 50 per cent faster than the hand operation.

Automatic Grinding Saves Time, Men,

BY JOHN W. LANE

A RELATIVELY SIMPLE MACHINE has converted hand grinding to automatic grinding in the James Foundry Corporation, Fort Atkinson, Wis.

James is primarily a manufacturer of malleable iron pipe fittings: these account for some 90 per cent of the foundry's work. Until about 18 months ago, grinding of the gate and/or riser ends of the fittings was done by hand. Hand grinding had many disadvantages, not the least of which was high cost.

In a hand operation the workman presses the fitting against a grinding wheel by hand. Valleys soon appear in the wheel and it must be dressed often. The job is dirty, slow, monotonous, and dangerous, especially if the operator does not pay attention to his work.

William Belstner, foundry superintendent, says he cannot keep a man at the hand grinding job more than two hours at a time. The man's hands become numb, his efficiency drops, and he is more prone to accidents.

Automatic grinding has eliminated virtually all these disadvantages. The James' system consists of a turntable which slowly revolves. Fitted into the top are flat dies forming a circle.

Into the outer perimeter of the dies, at about two-inch intervals, curved slots have been machined and shaped to receive the elbow of a pipe fitting. Each fitting is placed in a slot by hand, and the surface to be ground extends outward from the revolving turntable so that it will make contact with a vertical grinding wheel that is positioned 180 degrees from the operator.

As the fitting comes in contact with the face of the grinding wheel, the excess metal is ground off smoothly and evenly. Because the fitting passes across the complete face of the wheel, the grinding surface is worn evenly as well, and Belstner says he has never had to dress a wheel.

James now has two of these automatic grinders in operation, one for one-half inch elbows and another for three-quarter inch elbows. Mr. Belstner says he plans eventually to put at least three more in use and he hopes to modify the present system so that by using an overhead grinding wheel in conjunction with the vertical one, he can grind the two surfaces of T fittings—one at the gate end and the other at the riser end.

Using automatic grinders, a man can grind about 50 per cent more castings per hour than by grinding by hand. His job is a simple one: castings are fed into a tray at his right hand from an overhead grav-

2. As the fitting comes in contact with the face of the grinding wheel, excess metal is ground off smoothly and evenly. It passes across the complete face of the wheel, eliminating uneven wear.

3. With the system, grinding wheels should be able to handle 500,000 pieces before being replaced. The hand grinding operation limited a wheel's life to about 65,000 pieces.

and Money

ity feed hopper. After grinding, each fitting is automatically dropped into a bin at the worker's left by means of a steel rod that knocks each piece out of the turntable while still revolving.

The grinding wheels now in use have ground about 300,000 and 250,000 pieces, respectively. Belstner says he believes that each wheel should grind about 500,000 pieces before being replaced. When the fittings were hand ground, wheels had to be replaced after grinding about 65,000 pieces.

This means that at about $150 per wheel, it cost nearly $1,200 for eight wheels to grind 500,000 pieces by hand.

With substantial savings in the cost of grinding wheels, dressing of wheels, increased output of operators and a vastly improved safety factor, Belstner is completely sold on automatic grinding.

4. After the pipe fitting crosses the wheel, it is pushed from the slot by a steel rod and deposited into a waiting tote box. Plans for a system using an overhead wheel as well as the vertical wheel will make it possible to grind two surfaces of a fitting at the same pass.

PLANNING FOR CAPITAL INVESTMENTS

Many segments of the metalcasting industry are moving swiftly toward mechanization and automation. Decisions to buy equipment—to modernize—and to expand plants are being made daily.

—Large sums of money are at stake.

—Many people participate in making the decision.

This was highlighted recently when it was revealed that 85 per cent of MODERN CASTINGS' readers had a say in the buying program of their companies. With this in mind, John B. Polfelt of the General Iron Works, Denver, Colo., takes a look at the ways open to management in determining the profit value in capital expenditured.

Hemmed in by antiquated depreciation laws on one side and the sting of competition on the other, metalcasters daily face the problem of realizing a fair profit.

Unless a foundry can demonstrate its ability to produce better quality castings at a lower price, it faces the economic fact of extinction. Reaching this goal today usually requires intensified research, modern equipment, or increased production facilities. No matter the way or method used, the program calls for spending money—well-planned capital outlay.

Management must decide how to spend the money, and, most important, how to get the greatest return for the money spent. Two roads ahead can lead to failure. The company can (1) spend too much, or (2) spend too little.

If too much is spent, it is possible that the overloaded overhead will result in excessive production capacity and the inability to bid competitively. If too little is spent, it can mean antiquated production facilities and processes will burden the company with killing operating expenses. Either way, the company can fail completely.

Top management holds the responsibility for preserving a delicate and intricate balance between these two possibilities. Long range objectives must be served as well as short range needs. Every dollar spent or saved must be accounted for to minimize financial risk.

A basic first step toward expansion or capital outlay for equipment is a serious cost reduction program. This is particularly important today in the light of lagging casting orders. A $50 decrease per month in expenses, over a year's time, is equal to a $10,000 order, assuming a profit margin of six per cent.

If cost reduction is successful, the returns will eventually be minimized. This is when attention is focused on the potential profit to be gained from investing in new assets to assure a major new cost reduction.

Management is charged with determining the financial yardstick to be used to assure the highest rate of return on the capital investment. This yardstick is used to establish a priority list which pinpoint projects with the highest rate of return.

The most popular method for measuring attractiveness of investments is the "Pay-Off" method. Assuming a piece of equipment costs $1000 and will yield a constant $500 in operating savings each year over its life, it is said that the equipment has a two-year pay-off period. This, actually, is closer to a cash-break-even point.

Disregarding taxes and other considerations for the sake of simplicity, the rate of return on the investment is actually zero for the first two years, whereas the rate will equal 25 per cent for a life of four years and 34 per cent for six years.

The real problem involved in planning is how to determine if an investment in a five-year asset with a two-year pay off period stacks up better than a

10-year asset with a three-year or four-year pay off period.

Those concerned with the "actual" capital recovery period must take into consideration the type of depreciation used by the company. In a series of examples, a 10-year asset (equipment or building) can be written off 67 per cent in the first five years using the "declining balance" method and 72 per cent using the "sum-of-the-years-digits" method. The old straight line method, on the other hand, produces only a 50 per cent write-off.

The straight-line method of computing depreciation is predicated on the assumption that wear and tear are uniform during the useful life of the equipment. The cost of the item—less its estimated salvage value—is depreciated in equal amounts over the estimated useful life.

The sum-of-the-years-digits method is more accurrately based on the assumption that the depreciation is higher in the early years and lower in the later years. The years-digit assumes different fractions for each year of depreciation against the orginal cost, less salvage value. The numerator of the fraction represents the remaining useful life of the item each year, and the denominator, which always remains the same, represents the sum of the digits of all the years corresponding to the extimated longevity.

For example; a core blower with an estimated life of four years has a denominator which always equals 10 since the sum of four years, three years, two, and one adds up to 10. For the first year, four-tenths of the cost (less salvage value) would be the depreciation figure, and three-tenths the second year, etc.

Declining Balance as Base

The declining-balance method uses a depreciation base which is lowered each year by the amount of depreciation deduction and a steady rate is applied to the balances that result. Under tax provisions, this rate may be as high as 200 per cent of the straight-line rate.

There are reasons for choosing any method, and these are a matter of company policy in most instances. The yearly write-offs are usually considered as reinvested in the business and are considered to have the same earning power as ordinary company funds. The total value of this depreciation or "sinking" fund equals the accumulated depreciation charges plus the profits from reinvestment.

One of the first steps in determining the approach to a capital investment is to establish a life of the proposed asset for determining the write-off expense. Many companies set abritrary write-off periods of three or five years or another low figure. These are usually shorter than the reasonably estimated economic life of the equipment and result in a more conservative study.

It makes more sense to consider each case by itself, in relation to past experiences and reasonable future estimates. Unjustified short write-off periods result in an inventory of assets which should have been replaced a long time before.

Each case must be considered from the view of operating savings and advantages. It must be viewed, too, in the light of declining tax depreciation, which can be very important if it results in an unfavorable tax situation.

Despite all attempts at care in setting up the program of investment, there are always pitfalls to be avoided. This means that a systematically prepared and pretested approach should be the greatest help.

Several investment formulas are available. One, the MAPI (Machinery and Allied Products Institute) formula, has received publicity and attention in the metals field. It was first presented by George Ter-

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The Federal Tax Credit Plan

Metalcasters want to spend money in capital improvements—if the Federal Government provides for effective liberalization of depreciation laws.

Direct surveys in the metalcasting field by MODERN CASTINGS and surveys in the over-all metalworking field prove that over half the metalworking industry would spend six per cent more than they are spending now if they can get a decent tax break.

The initial tax credit plan proposed by the administration was not favorably received. It was criticized as discriminatory against smaller firms, as completely inadequate in a time when sweeping reform is needed, and as the wrong approach to a vital problem.

A new plan proposes, in effect, a special first-year eight per cent write-off on all new plant and equipment. It falls short of the original sliding scale plan proposed by President Kennedy which allowed up to a 15 per cent credit for plant and equipment spending—if that spending exceeded a firm's depreciation allowance by stipulated amounts.

The administration had asked that the amount of tax credit claimed be limited to no more than 30 per cent of the total income tax due. The committee raised the limit to 50 per cent. This means credit can't reduce taxes more than 50 per cent.

Smaller businesses got something of a break from the committee. One feature is the removal of the 50 per cent limitation for firms with annual earnings up to $100,000. The other permits the purchase of used equipment up to $50,000 for credit purposes.

Even this plan, considered a compromise for both sides, may not get final approval until 1962. As a one-shot plan, it could conceivably be an obstacle to the general reform which is so direly needed.

It is up to metalcasters as well as others in industry to work for some kind of legislation that will make it possible for intelligent expansion of facilities, equipment and services to provide the working tools for better castings.

Determining Next-Year Rate of Return

The six steps of the MAPI (Machinery and Allied Products Institute) formula for calculating the "next-year rate of return" on an asset purchased this year rather than next year can be illustrated in metalcasting terms.

Assume that an old sand mixer needs an overhaul if it is to be kept in service. This overhaul will cost $2000 and is expected to add five more years to its service. A new mixer will save overtime and maintenance expenses, but it means a capital outlay of $15,000. Which is the better way of achieving a fair return?

1. Calculate the required net investment:
   Installed Cost $15,000

   Disposal value of old mixer .. $ 500
   Cost of overhaul $2000

   Investment released by new mixer $2500

   Required net investment $12,500

2. Determine operating advantage:
   Annual expense of old mixer including labor, main., ins., taxes, etc. $11,000

   Same expense new mixer .. $ 8,000

   Net operating advantage .... $ 3,000

3. Figure non-operating advantages and "next-year capital consumption avoided" factors:
   Next year capital allocation for the overhaul $2000

   Divided by estimated economic life of the old mixer .. 5 years

   Equals a non-operating advantage of .... $ 400

   Total "next-year" advantage ...... $ 3,400

4. Subtract income tax rate (assume 50%) from this figure to arrive at after-tax advantage .... $ 1,700

5. Apply the MAPI allowance:
   Using double-declining-balance- depreciation method, the allowance is 4.4%. $15,000 × .044 .... $ 660

6. Subtract allowance from after-tax advantage .... $ 1,040

   To determine the "next-year rate of return" divide the amount available for return on investment ($1040) into the net investment ($12,500) to arrive at rate of return for project 8.3%

borgh, MAPI research director, in 1944 and modified several times since then.

The formula produces a figure called "the next year rate of return"—the result of an investment in an asset made now rather than waiting for a year.

The formula is composed of six parts (See an example on this page):

1. The required net investment must be figured by using the installed cost of the project. From this is subtracted either the disposal value of the old equipment or the money which must be spent to keep the old equipment operating. In cases where replacement is not involved, the net investment is the same as the installed cost.
2. Second to be considered is the operating advantage or "saving" of the new equipment over the old. This should include effect on direct and indirect labor, production volume, down-time maintenance, scrap, taxes, etc.
3. The "non-operating advantage" and the "next-year capital consumption avoided" factors are calculated. If the proposed installation is delayed, the existing equipment's salvage value may decrease after another year's use. Some money may be used to improve efficiency, as well. Part of the overhaul expense is charged to this year if it is regarded as a capital cost. The total of these figures make up this portion of the formula.
4. Subtract the income tax from the totaled preceeding "advantages" (steps 2 and 3), using the applicable tax rate.
5. Apply the MAPI allowance. This is the focal point of the method and has been questioned and debated. It is computed with the help of charts based on the frozen conditions of 25 per cent debt ratio, 3 per cent debt interest rate, and an after-tax equity return of 10 per cent. An assumed income tax rate of 50 per cent is included but can be modified by using adjustment factors. The write-off period and the type of depreciation enter into the selection of the allowance. The result of this computation is the presumed part of the installed cost of the project, which will now be written off in the first year as the cost for the use of capital.
6. After subtracting the allowance from the after-tax advantage, the amount available for return on investment is reached. This is divided into the required net investment. The result is the rate of return of the proposed project or the "next-year rate of return."

This formula does not guarantee any answers, for it cannot produce any truer rate of return than the facts and estimates used for calculations. If the figures compiled are correct, the MAPI allowance method presents management with a consistent and pretested investment guide. It forces management to consider important factors that might otherwise be ignored or forgotten.

Take Five Minutes to Think!

What fire extinguisher is best for an electrical fire? What causes the most severe burn, molten iron or molten aluminum? Here's another opportunity to test your Foundry Safety IQ. If you think the statement is true, place a T in the box. If you disagree, place an F in the box.

1. Leggings worn by men handling molten metal can be the cause of more leg burns than if no leggings are worn at all. ☐
2. Portable soda-acid fire extinguishers should be readily accessible especially in case of electrical fires. ☐
3. A speed limit of ten miles per hour should be established for all lift trucks. ☐
4. If a man is struck in the eye by molten metal, he should be taken immediately to an optometrist for treatment. ☐
5. A splash of molten aluminum (1211 F) will cause a more severe burn than a splash of molten iron (2795 F). ☐
6. Before doing maintenance work on electrically operated power machinery, the safe procedure is to first open the electric circuit and then affix a warning tag to the switch. ☐
7. When pouring a mold with aluminum there is greater danger of getting burnt than when pouring the same mold with iron. ☐
8. When planning a program of eye protection, a survey should be made first to determine in which departments eye protection shall be mandatory. ☐
9. Since the exception proves the rule, there are times when the rule can be waived, as during the breakdown of equipment. ☐
10. As the *subtended* angle on a double branch chain attached to two sides of a flask increases, the load limit of the chain decreases. ☐

Okay—now you can check the correct answers in the column at the right. Score 10 points for each correct answer. If you have all 10 correct, you are a safety expert and will save yourself from many painful experiences. If you rated about 50, you had better get a copy of the AFS SAFETY MANUAL and do some studying. If you scored under 50, you're working on borrowed luck.

Answers to Safety Test

1. True. Unless the pants are cuffed over the leggings, metal can get trapped behind them.
2. False. Soda-acid fire extinguishers should never be used on electrical fires. The CO_2-water mixture discharged from the extinguisher is a good conductor of electricity. Severe shock could result.
3. False. Speed limits should be established for each condition. In some cases, 10 mph is too fast; in others, it may safely be exceeded.
4. False. An optometrist is not qualified to treat eye injuries. The man should be taken to an opthalmologist—an eye physician.
5. True. Iron on solidifying as it strikes a man gives off only $\frac{7}{10}$ as many heat units as aluminum when it solidifies.
6. False. The circuit should be opened; a warning tag affixed and *the switch locked out.*
7. True. Molten aluminum is less viscous than molten iron hence there is a greater possibility of getting run outs and leaks.
8. False. There is no need for the survey. Everyone in every department should have eye protection.
9. False. There have been too many injuries and deaths because the safety rule was waived for expediency. There are no exceptions to a sound safety rule.
10. True. On a one-half inch link-size chain, when the angle at the hook is 60°, a safe load is 9.7 tons; at 90°, the safe load is 8.0 tons; and at 120°, the safe load is 5.6 tons.

AFS New Technology-1961

August Contents

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About The New Technology

Here are 64 more pages of New Technology—selected breakthroughs in the metalcasting field which appear exclusively in Modern Castings in 1961.

Interpretive summaries of all New Technology for 1961 appeared in the May issue (pages 69 to 84). These nine articles are published for the first time since their presentation in San Francisco at the 65th Castings Congress.

These breakthroughs are the most important new technological advances in metalcasting. They were authenticated as new contributions by a 600-man technological committee guided by a member of the editorial and professional staff, S. C. Massari, AFS Technical Director. The section is edited by M. C. Hansen.

All New Technology is further evaluated by Modern Castings editors for their significance as practical tools today. Written comments or criticisms of these articles will be included in the 1961 AFS Transactions if submitted before September 15, to AFS Headquarters, Golf & Wolf Rds., Des Plaines, Ill.

GREEN SAND PROPERTIES

Median grain size effect

by A. B. Draper and H. A. Knappenberger

ABSTRACT

Foundrymen are becoming more aware that variations in sand grain size and distribution affect both the properties of molds and the quality of castings. This paper reports the effect of median grain size on the green compression strength and permeability of molding sand.

Previous research failed to isolate the effect of median grain size from other distribution parameters. The present investigation overcomes this deficiency by synthesizing symmetrical sand distributions of varying median grain sizes but with equal dispersion.

The results support the generally accepted statement that permeability increases as median grain size increases, but they refute the theory that green compression strength increases as median grain size decreases. It follows that the green compression strength of rammed molding sand does not depend upon the total sand grain surface area or the number of sand grain points of contact.

INTRODUCTION

Foundrymen have long known that consistently acceptable castings require close control of molding sand properties. Such control can be achieved by good laboratory techniques if they are properly correlated with both the properties of the mold and casting defects. The foundry engineer could achieve greater control of casting quality if he better understood the effect and interaction of sand grain distribution parameters on mold properties; intuition is not enough.

At least four areas must be investigated before the sand technician will have sufficient understanding to use his molding materials to best advantage, or before a meaningful sand classification system can be developed. These are the effect upon mold properties of variations in:

1. Grain size.
2. Grain size distribution.
3. Grain shape.
4. Electrochemical forces at the sand-clay-water interface.

Schubert[1] studied several commercially available sands and reported that increases in the AFS grain fineness number decreased the AFS permeability values but had no effect on the green compression strength. Schubert's work is inconclusive, however, because the AFS grain fineness number is merely a measure of average grain size (Morey and Taylor,[2] Leaman and Ekey[3]), and he failed to control other distribution parameters such as skewness and dispersion.

This research investigated the effect of average grain size on the green compression strength and permeability of synthetically bonded green sand. The information obtained may eventually lead to the development of a meaningful sand classification system.

PROCEDURE

Sieve fractions of Ottawa rounded sand grains were prepared in sufficient quantity to construct five different sand grain size distributions. Each had constant dispersion, no skewness, and a different median grain size. All distributions were bonded to successively higher levels of southern bentonite, mulled for a standard time and then tempered to a moisture level somewhat higher than that required for maximum green compression strength.

After test specimens were evaluated for green sand properties with standard laboratory equipment, the sand was exposed to the atmosphere and retested at

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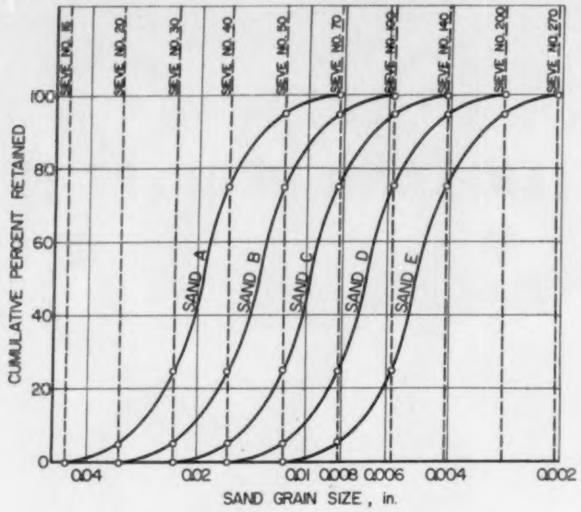

Fig. 1 — Cumulative frequency distribution for five test sands.

the lower moisture content. Curves for green compression strength versus moisture were established. Then the test sands were dehydrated, rebonded to a higher binder level and tested as before.

Building Test Distributions

To eliminate disparities in dispersion and skewness, known sieve fractions were combined to yield symmetrical sand grain distributions with equal dispersion but varying average grain size (Table 1). The effect of grain shape was minimized by using only Ottawa silica sand, which has rounded grains. The cumulative frequency distribution curves (Fig. 1) show the similarity of the distributions and yield the median grain size directly. This is convenient because in a symmetrical distribution both the median and the arithmetic average are equal, but the latter is more difficult to determine.

Bonding and Tempering Test Sands

Since several investigators had reported that southern bentonite reaches peak green compression strength in a shorter mulling time than any other binder, it was selected for this work. To include binder levels both typical of foundry practice and within the region of clay saturation (Zrimsek and Heine[4]), four bentonite levels were chosen in an approximate geometric progression, 5, 8, 12 and 20 per cent.

Contrary to customary practice, these percentages were based on the total sand and binder content rather than on the sand alone (e.g., 52.4 gm of binder and 1000 gm of sand for the first test run). After mulling the dry mixture for 5 min, water slightly in excess of that required for peak green compression strength was added and the mulling was continued for 5 min.[5]

Recent research[6] indicated that the moisture required to develop maximum green compression strength could be determined analytically. However, that method proved to be inadequate (Appendix),

TABLE 1 — TEST SAND DISTRIBUTIONS

U.S. Stand. Sieve No.	Mesh Size Openings, in.	Sand A Weight Gm.	Sand A %	Sand B Weight Gm.	Sand B %	Sand C Weight Gm.	Sand C %	Sand D Weight Gm.	Sand D %	Sand E Weight Gm.	Sand E %
20	0.0331	50	5								
30	0.0232	200	20	50	5						
40	0.0165	500	50	200	20	50	5				
50	0.0117	200	20	500	50	200	20	50	5		
70	0.0083	50	5	200	20	500	50	200	20	50	5
100	0.0059			50	5	200	20	500	50	200	20
140	0.0041					50	5	200	20	500	50
200	0.0029							50	5	200	20
270	0.0021									50	5
Median grain size, in.		0.0195		0.0135		0.0098		0.0069		0.0051	
A.F.S. Grain Fineness number		30		41		54		74		105	

and the proper moisture levels for the materials used in this research were established by qualitative tests. The tests showed that a southern bentonite bonded sand tempered to maximum green compression strength appeared slightly damp but felt distinctly dry. By tempering a little beyond this point and decreasing the water content, the desired curves for green compression strength versus moisture could readily be obtained. The tempered mix was aged for at least 12 hr in sealed glass jars before being riddled through a 20 mesh sieve and tested.

Testing Procedure

A standard moisture teller was used in conjunction with a desiccator for cooling the specimens before reweighing. If two tests were inconsistent, a third test was made.[5]

Four standard AFS specimens from each distribution were tested for permeability, hardness and green compression strength (Table 2), according to AFS procedures.[5] Two exceptions should be noted:

1) If the permeability was in excess of 500, the stop watch method was used.
2) If the compression strength exceeded 18.5 psi, the next specimen was tested in the upper position on the testing machine.

TABLE 2 — TEST DATA FOR RIDDLED AND UNRIDDLED OTTAWA SAND, AFS No. 130, 2.2% MOISTURE, 6% SOUTHERN BENTONITE*

Specimen Property	Riddled Sand	Unriddled Sand
AFS Permeability	79	64
AFS Hardness	91	91
Green compression strength, psi	10.5	9.5

*All data is an average of 3 tests.

Because of the labor involved in obtaining the original sand distributions, as much sand as possible was reclaimed. To implement this policy, the sand was exposed to the atmosphere to allow some moisture (approximately 0.25 per cent) to evaporate, then

mulled for 3 min, riddled into glass jars, sealed and retested after proper aging. Thus, the green sand property variations as a function of moisture could be determined in the vicinity of the maximum green compression strength by using only three or four tests.

TABLE 3 — MAXIMUM DEVELOPMENT OF GREEN COMPRESSION STRENGTHS (psi) FOR THE FIVE TEST SANDS AT THE FOUR BINDER LEVELS

Test Sands	Median Grain Size, in.	Green Compression Strength as a Function of S.B. Content			
		5 %	8 %	12 %	20 %
A	0.0195	14.4	25.8	29.1	30.4
B	0.0135	15.4	29.3	37.2	31.2
C	0.0098	16.3	29.8	34.9	29.4
D	0.0069	15.9	29.1	38.9	31.7
E	0.0051	17.4	30.5	36.4	30.1

The repeated use of the sand grains could be criticized on the following grounds:

1) Excessive mulling might crush the sand grains, changing the grain size distribution and the average activity of the grain surface.
2) The green compression strength of the sand might increase with increased mulling.

It was unlikely that significant crushing of the sand grains could occur, since the muller wheels were rubber. In any case, the permeability did not decrease with increased mulling. The second objection must be invalid, for this research established that there was no significant difference in green compression strength, regardless of cause, within the limits of the experiment. It should also be remembered here that southern bentonite was chosen as a binder for the precise reason that it reaches its peak compression strength with minimum mulling.

TABLE 4 — ANALYSIS OF VARIANCE FOR THE DATA IN TABLE 3

Source of Variation	Sum of Squares of Deviations	Degrees of Freedom	Mean Square Deviation	F Ratio	F_{95}	F_{99}	Significant? 95%	Significant? 99%
Median grain size	41.133	4	10.283	0.107	3.26	5.41	No	No
Bentonite level	1035.428	3	345.143	3.7	3.49	5.95	Yes	No
Residual	1113.188	12	92.766					
Total	2189.749	19						

There were two principal advantages in reusing the sand. Variations in sand distribution from test to test were constant, and variations in mesh size openings caused by sieving large quantities of sand were minimized.

Increasing the Bond Content

Before increasing the bond content, the sand was completely dehydrated in an electric oven at 215 F. Calcium chloride desiccant was placed in the oven during cooling to prevent the readsorption of moisture. Assuming that 5 per cent of the binder remained, sufficient new southern bentonite was added to give an 8 per cent binder content. A similar procedure was followed for the sands with 12 and 20 per cent binder (Tables 5 to 9).

EXPERIMENTAL RESULTS

Maximum green compression strength occurred at higher moisture levels as the amount of binder increased (Fig. 2). At 12 per cent binder, only three points were tested because this seemed adequate. It proved to be unwise, and the four-point procedure was resumed.

The maximum green compression strength increased with increasing bond, up to a southern bentonite content of approximately 12 per cent (Fig. 3). At 20 per cent binder, the maximum green compression strength decreased. This substantiates the existence of a binder saturation point in the region from 12 to 15 per cent.

Further analysis suggested that median grain size has no effect on the maximum development of green compression strength. The proposition was tested by an analysis of variance[7] (Tables 3 and 4). This test showed that at both the 95 and 99 per cent confidence levels the median grain size had no effect on the green compression strength.

The effect of southern bentonite level on the green compression strength was also tested. The test showed that at the 95 per cent confidence level bentonite content had a detectable effect, but at the 99 per cent confidence level it had none. This conclusion is reasonable, considering that three of the four bentonite levels tested were so close to the binder saturation range of southern bentonite that changes in binder content had little effect upon green compression strength. However, it is common experience that sands with, let us say, 3 to 8 per cent southern bentonite binder (definitely below the saturation range) do exhibit significant increases in green compression strength with increasing binder content.

Permeability-Moisture Relationship

Peak permeability was not achieved in any of the tests. However, the data obtained support the generally accepted statements that maximum permeability increases as the grain size increases, and that greatest permeability occurs at a higher moisture level than does peak green compression strength.

SUMMARY AND CONCLUSIONS

An analysis of variance indicates that at the 99 per cent confidence level median grain size has no effect on the maximum development of green compression strength in molding sands.

The data also support three commonly accepted statements relative to permeability:

1) Large sand grains produce higher permeability than smaller sand grains when bonded under identical conditions.
2) Peak permeability occurs at a moisture content higher than that required for peak green compression strength.

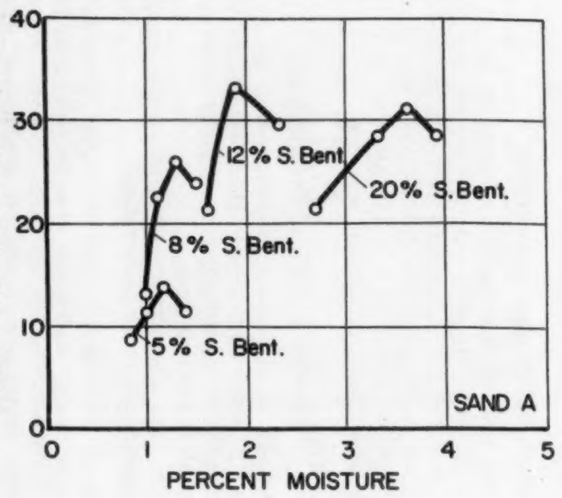

Fig. 2a and 2b — Typical green compression strength vs. moisture content for the test distributions.

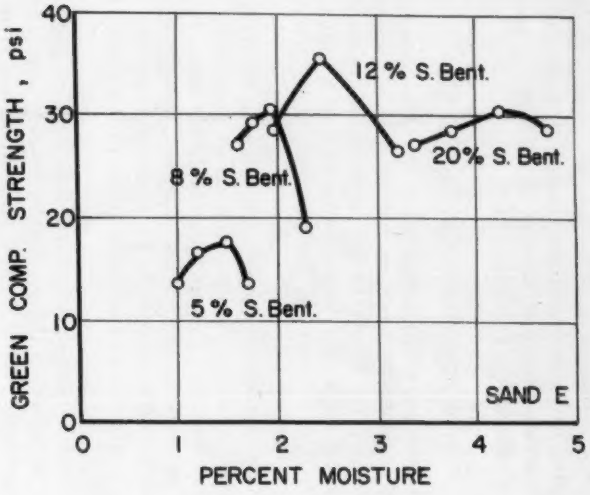

TABLE 5 — EXPERIMENTAL DATA FOR SAND A

			AFS Permeability					AFS Hardness					Compression Strength, psi					
Sand No. 1	S. Bent., %	Moisture, %	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Avg.	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Avg.	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Avg.	Specimen Weight, gm
A-1.1	5	1.4	650	650	650	650	650	93	94	93	93	93	11.3	11.6	10.5	10.6	11.0	163
A-1.2	5	1.1	650	650	650	650	650	96	96	96	95	96	15.1	—	13.3	14.8	14.4	164
A-1.3	5	0.90	650	575	575	575	594	96	97	97	96	96	—	12.3	12.6	10.7	11.9	169
A-1.4	5	0.70	550	575	500	500	531	99	98	99	98	98	7.8	8.0	9.5	7.0	8.1	170
A-2.1	8	1.5	600	600	650	600	613	95	94	95	95	95	24.2	24.0	24.7	24.5	24.3	164
A-2.2	8	1.25	525	525	500	500	513	97	97	97	96	97	25.8	26.2	25.5	25.5	25.8	169
A-2.3	8	1.1	500	500	490	500	498	94	95	95	95	95	25.5	23.0	20.5	22.1	22.8	169
A-2.4	8	0.9	450	450	500	575	494	93	94	93	93	93	—	15.2	—	10.1	12.6	171
A-3.1	12	2.35	550	550	525	550	544	94	94	94	95	94	28.0	29.1	29.4	29.8	29.1	166
A-3.2	12	1.8	525	475	500	500	500	96	98	97	97	97	37.0	38.2	29.8	28.7	33.4	169
A-3.3	12	1.55	400	425	450	450	431	97	96	96	96	96	16.7	20.2	19.8	24.2	20.2	170
A-4.1	20	3.9	575	600	600	650	606	93	93	93	93	93	28.8	28.2	29.1	28.9	28.8	159
A-4.2	20	3.3	435	450	400	—	428	95	95	96	—	96	28.3	28.4	28.2	—	28.6	165
A-4.3	20	2.7	250	325	325	425	331	96	95	96	96	96	—	20.7	19.5	21.7	20.6	168
A-4.4	20	3.6	400	375	400	410	396	95	96	95	96	96	—	29.1	32.5	29.7	30.4	166

TABLE 6 — EXPERIMENTAL DATA FOR SAND B

Sand Specimen No.	S. Bent., %	Moisture, %	AFS Permeability					AFS Hardness					Compression Strength, psi					Specimen Weight, gm
			Spec. 1	Spec. 2	Spec. 3	Spec. 4	Avg.	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Avg.	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Avg.	
B-1.1	5	1.4	360	395	390	350	374	95	96	94	94	95	13.4	13.6	13.0	13.2	13.3	160
B-1.2	5	1.3	350	350	325	330	339	97	97	97	97	97	14.6	16.1	15.2	15.7	15.4	163
B-1.3	5	1.1	325	330	300	325	320	97	97	98	97	97	12.1	12.0	12.3	12.3	12.2	164
B-1.4	5	1.0	375	360	330	330	344	95	95	95	95	95	12.1	12.4	10.6	10.1	11.3	161
B-2.1	8	1.65	380	385	360	365	373	94	94	94	94	94	24.0	24.7	25.5	24.6	24.7	161
B-2.2	8	1.4	265	300	280	275	280	97	97	97	97	97	27.5	29.5	29.7	30.5	29.1	167
B-2.3	8	1.3	250	250	240	255	254	96	97	95	96	96	31.5	29.5	27.0	28.5	29.3	169
B-2.4	8	1.1	260	240	245	250	249	96	96	96	96	96	16.2	22.6	17.4	16.7	18.2	169
B-3.1	12	2.7	375	325	350	375	356	93	93	93	94	93	29.7	29.4	29.0	29.2	29.3	160
B-3.2	12	2.1	280	240	260	265	261	97	97	98	97	97	36.0	38.0	37.1	37.7	37.2	167
B-3.3	12	1.65	195	198	215	220	207	98	97	98	97	98	26.1	35.5	23.7	29.7	28.8	168
B-4.1	20	4.4	425	450	425	—	433	90	90	90	—	90	27.0	29.2	27.8	—	28.0	152
B-4.2	20	3.8	230	225	250	245	238	95	96	95	95	95	30.2	29.8	31.0	29.0	30.0	161
B-4.3	20	3.4	160	145	170	180	164	97	96	96	96	96	27.8	26.7	25.7	26.6	26.7	167
B-4.4	20	4.05	320	325	350	330	331	94	94	95	93	94	30.3	29.8	32.7	32.1	31.2	159

TABLE 7 — EXPERIMENTAL DATA FOR SAND C

Sand Specimen No.	S. Bent., %	Moisture, %	AFS Permeability					AFS Hardness					Compression Strength, psi					Specimen Weight, gm
			Spec. 1	Spec. 2	Spec. 3	Spec. 4	Avg.	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Avg.	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Avg.	
C-1.1	5	1.6	180	190	195	195	190	95	94	95	95	95	14.5	13.4	14.4	13.7	14.0	157
C-1.2	5	1.4	175	185	180	175	179	95	97	96	97	96	16.1	16.6	16.4	16.3	16.3	160
C-1.3	5	1.1	150	150	150	155	151	96	97	95	96	96	12.6	14.8	12.9	12.1	13.1	163
C-1.4	5	0.9	125	130	125	120	125	96	97	96	98	97	6.4	7.6	6.7	7.1	6.9	165
C-2.1	8	1.7	165	155	150	150	155	95	94	95	95	95	25.2	25.8	24.5	26.1	25.4	159
C-2.2	8	1.6	130	127	125	130	128	96	96	96	96	96	30.5	30.5	29.5	28.7	29.8	167
C-2.3	8	1.4	130	127	120	125	126	95	96	95	97	96	28.4	29.8	28.7	28.2	28.8	166
C-2.4	8	1.1	127	110	125	120	121	96	96	97	97	97	17.8	20.6	20.4	18.2	19.2	167
C-3.1	12	2.6	190	180	185	180	184	94	92	93	93	93	29.5	30.5	30.2	30.6	30.2	158
C-3.2	12	2.2	115	118	115	120	117	98	98	97	97	98	—	39.5	32.3	32.8	34.9	167
C-3.3	12	1.4	95	95	95	100	96	97	98	97	97	97	29.8	29.7	27.7	26.0	28.3	170
C-4.1	20	4.5	185	187	182	180	184	92	93	93	93	93	27.7	29.5	28.4	29.1	28.7	153
C-4.2	20	3.9	105	100	105	102	103	96	95	95	96	96	—	29.4	29.2	29.7	29.4	163
C-4.3	20	3.5	70	68	75	70	74	96	97	97	97	97	30.7	29.5	29.0	27.1	29.1	166
C-4.4	20	3.1	62	65	63	65	61	96	97	97	96	96	26.2	25.3	25.8	26.0	25.8	168

TABLE 8 — EXPERIMENTAL DATA FOR SAND D

Sand Specimen No.	S. Bent., %	Moisture, %	AFS Permeability					AFS Hardness					Compression Strength, psi					Specimen Weight, gm
			Spec. 1	Spec. 2	Spec. 3	Spec. 4	Avg.	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Avg.	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Avg.	
D-1.1	5	1.7	110	105	102	102	105	94	94	94	93	94	12.8	12.4	12.3	12.2	12.4	155
D-1.2	5	1.5	97	96	97	97	97	97	96	95	96	96	16.2	15.5	15.9	16.1	15.9	158
D-1.3	5	1.3	95	94	92	93	94	95	96	95	96	96	13.1	12.6	12.6	13.9	13.1	157
D-1.4	5	1.2	94	93	95	95	94	95	95	96	95	95	11.7	11.0	11.9	11.9	11.6	156
D-2.1	8	2.3	105	106	101	102	104	90	90	90	90	90	20.5	19.5	19.5	19.5	19.8	154
D-2.2	8	1.9	83	84	82	82	83	94	95	95	95	95	27.7	29.8	29.6	28.0	28.5	160
D-2.3	8	1.8	75	76	75	76	76	94	95	95	95	95	30.8	28.5	29.0	28.2	29.1	161
D-2.4	8	1.6	60	62	61	60	61	96	96	97	96	96	26.8	24.6	27.6	26.2	26.3	165
D-3.1	12	2.9	120	112	115	112	115	91	92	91	91	91	26.0	26.5	26.2	26.7	26.3	153
D-3.2	12	2.4	67	66	65	68	67	97	96	97	97	97	38.7	40.9	37.6	38.3	38.9	162
D-3.3	12	2.0	54	52	54	56	54	96	97	97	97	97	30.5	35.1	30.4	33.7	32.4	167
D-4.1	20	4.9	145	150	140	145	145	90	89	90	89	90	28.6	28.4	29.5	29.1	28.9	147
D-4.2	20	4.05	72	72	74	74	73	94	94	94	95	94	—	31.5	30.0	33.5	31.7	156
D-4.3	20	3.7	47	48	51	50	49	96	96	96	96	96	28.2	28.7	30.2	28.7	28.9	162
D-4.4	20	4.6	110	105	112	112	110	93	93	93	94	93	30.3	29.8	29.3	30.8	30.1	151

TABLE 9 — EXPERIMENTAL DATA FOR SAND E

Sand Specimen No.	S. Bent., %	Moisture, %	AFS Permeability					AFS Hardness					Compression Strength, psi					Specimen Weight, gm
			Spec. 1	Spec. 2	Spec. 3	Spec. 4	Avg.	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Avg.	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Avg.	
E-1.1	5	1.7	61	61	60	59	60	94	94	93	94	94	13.9	13.5	13.5	13.0	13.5	153
E-1.2	5	1.5	54	55	55	55	55	96	96	96	96	96	17.3	17.2	17.5	17.5	17.4	156
E-1.3	5	1.2	48	48	49	48	48	96	96	96	97	96	16.5	15.5	14.9	16.6	15.9	157
E-1.4	5	1.0	45	45	45	45	45	97	97	97	97	97	13.3	13.1	13.5	13.1	13.2	158
E-2.1	8	2.25	58	59	58	59	59	89	89	89	89	89	19.5	19.5	19.5	19.0	19.4	153
E-2.2	8	1.9	47	48	47	47	47	95	95	95	95	95	32.8	32.4	28.2	28.7	30.5	158
E-2.3	8	1.7	43	43	43	44	43	94	94	95	95	94	29.0	31.2	28.5	28.7	29.3	160
E-2.4	8	1.6	36	35	35	36	36	96	97	96	96	96	29.7	28.1	27.5	26.2	27.9	162
E-3.1	12	3.2	68	67	67	66	67	90	90	90	90	90	26.5	26.8	25.5	26.8	26.4	149
E-3.2	12	2.4	39	38	38	39	39	96	96	96	96	96	39.2	36.6	33.2	36.7	36.4	160
E-3.3	12	1.9	31	30	32	31	31	96	98	97	97	97	29.2	29.8	28.2	31.4	29.6	164
E-4.1	20	4.7	60	58	58	59	59	93	91	91	91	91	28.4	28.7	28.7	28.2	28.5	150
E-4.2	20	3.7	33	32	34	34	33	96	95	95	95	95	—	28.7	28.4	28.8	28.6	158
E-4.3	20	3.4	26	25	26	26	26	97	97	97	96	97	—	28.3	26.8	26.2	26.2	162
E-4.4	20	4.2	37	36	35	36	36	96	96	95	96	96	—	30.7	29.2	30.4	30.1	160

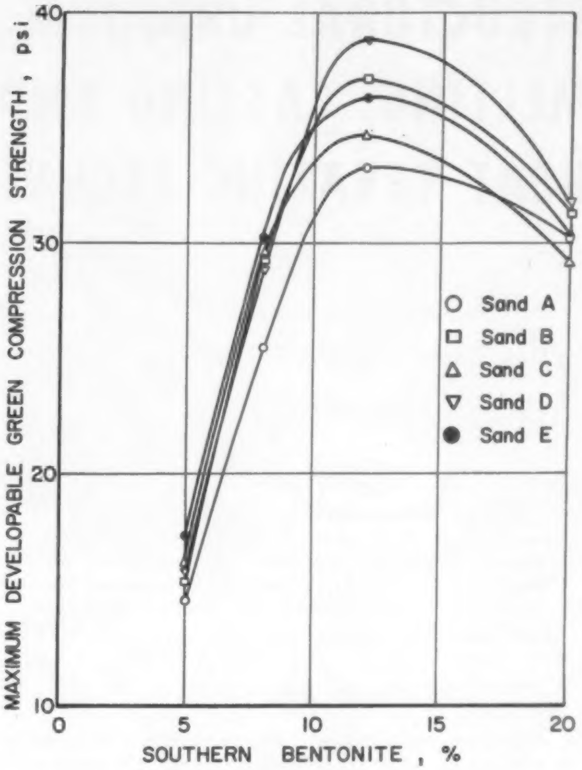

Fig. 3 — Maximum development of green compression strength vs. southern bentonite content for each of the five test distributions.

3) Higher binder levels require larger amounts of water in order to develop maximum permeability in any particular sand distribution.

As a result of this research, it must be concluded that whereas variations in median grain size have a considerable effect on permeability, they have little or no effect on green compression strength. Furthermore, the sand grain surface area and the number of sand grain points of contact have little or no effect upon the strength of the sand-clay bond.

Before the full impact of this information is realized, and before a more meaningful sand classification system can be devised, a better understanding of the factors that affect the sand-clay bond must be developed.

ACKNOWLEDGMENT

The authors wish to express their appreciation to Prof. G. L. Thuering of The Pennsylvania State University, whose advice was most helpful. The members of the Basic Concepts Committee of the Sand Div. of the American Foundrymen's Society, especially T. W. Seaton, made many useful suggestions and provided guidance and encouragement. The following companies generously supplied materials: American Silica Sand Co., Inc., Gopher State Silica, Inc., and Wedron Silica Co. The W. S. Tyler Co. furnished a full set of AFS standard sieves, and the Beardsley and Piper Div. of Pettibone-Mulliken Corp. contributed Laboratory equipment. The Pennsylvania State University supplied transportation, laboratory facilities and the secretarial work involved in this undertaking.

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APPENDIX

Comparison of Theoretical and Experimental Determinations of Moisture Required for Maximum Strength

THEORETICAL DETERMINATION

U.S. Standard Sieve Number	a Weight Retained (gm)	b Weight Retained (%)	c Moisture Factor[6] (gm water / gm sand)	d Moisture Required (column b x c / (%))
40	0.4	0.7	0.00587	0.004109
50	0.5	0.9	0.00834	0.007506
70	4.2	7.9	0.01177	0.092983
100	18.9	35.4	0.01662	0.588348
140	21.2	39.7	0.02380	0.944860
200	6.9	12.9	0.03320	0.428280
270	1.0	1.9	0.47020	0.139680
Pan	0.3	0.6	0.09100	0.054600

Total moisture required for sand (wt.-pct. basis) — 2.260360

[Total moisture required for maximum green compression strength] = [Moisture required for sand (94% of sand clay mixture)] + [Moisture required for 6 per cent southern bentonite]

Total moisture required = (2.26) (0.94) + 6 (0.15) = 3.0%

EXPERIMENTAL DETERMINATION*

Moisture, %	1.1	1.4	1.8	2.2	2.5	3.0
Green compression strength, psi	8.2	14.3	13.3	10.6	9.1	7.7

* All data is an average of three tests.

Experimentally determined moisture requirement for maximum green compression strength = 1.4%

STRUCTURAL URANIUM ALLOY MELTING, CASTING AND HEAT TREATING TECHNIQUES

by G. D. Chandley and D. G. Fleck

ABSTRACT

High strength uranium-base alloys are becoming more important in construction of nuclear and non-nuclear weapons. Watertown Arsenal has been producing uranium alloy parts for Army weapons for more than four years. The various techniques for handling these uranium alloys are described in detail.

INTRODUCTION

The most conventional use of uranium has been as a nuclear fuel. It is widely used in reactors to produce heat and various types of radiation. This is because the uranium 235 in natural uranium has an excellent ability to sustain a fission chain reaction. However, the percentage of uranium 235 in natural uranium is only 0.7 per cent, the remainder of the natural uranium being uranium 238. Therefore, in refining the uranium metal in order to obtain a higher percentage of uranium 235, most of the natural uranium becomes a by-product available for uses other than a nuclear fuel. Other general properties of uranium which warrant its use for non-fuel applications are:

1. Uranium has a remarkable ability among metals of reasonable cost to absorb large amounts of gamma radiation. For example, uranium will absorb 12 to 15 times as much gamma radiation as an equivalent thickness of steel. This encourages its use for shielding sources of intense radiation.
2. Structural uranium alloys have another distinct property—they are the heaviest structural metals developed to date. Their density of approximately 0.67 lb/cu in. is more than 50 per cent greater than the density of lead. Therefore, for applications requiring a high density combined with exceptional strength, uranium base alloys are outstanding.
3. The mechanical properties of uranium base alloys equals those normally expected of high strength steel. A 0.1 per cent offset yield strength of 140,000 psi can be obtained, and elongation of 15 per cent (reduction of area of 45 per cent) would be found at this yield strength level. Impact resistance is sensitive to minor impurities, but a charpy V notch impact energy of 5-8 ft-lb at -40 F can be obtained if the stock is vacuum heat treated.

Many classified applications have been developed for uranium alloys based on the above mentioned properties, and wider use of uranium is expected in the future as nuclear power is extended to more applications. Indeed it is quite conceivable that cast uranium alloys could some day play as important a part in space travel as cast aluminum and cast iron have played in ground travel.

FOUNDRY PRACTICE

General Chemical Behavior

Pure uranium is reactive chemically. It will decompose when exposed to air, forming uranium oxides and hydrides. Atmospheric corrosion is rapid, and highly polished pure uranium will turn completely black overnight if unprotected. The rate of reaction increases with temperature, and at elevated temperatures uranium forms a powdery black oxide which falls off the surface. If uranium is struck sharply with another object, or is sand blasted, a shower of sparks will be produced. As the temperature is raised to the melting temperature of 2090 F (1143 C), one finds that molten uranium will rapidly react in air forming uranium oxide, uranium nitride and uranium hydride.

Therefore, uranium, when molten, must be held under an inert atmosphere or good vacuum. Other important reactions which can occur in uranium processing are due to uranium's ability to form a low melting eutectic with iron and to react with carbon to form uranium carbides. Contact between uranium and these materials above 1340 F (727 C) must be avoided or contamination of the uranium will be found. Many refractory oxides are stable in contact with molten uranium and refactories as stable as zircon, magnesium oxide and mullite can be used for molds and crucibles.

When heated, uranium will dissolve hydrogen readily. A pickup of several parts per million of hydrogen will be encountered in heating uranium

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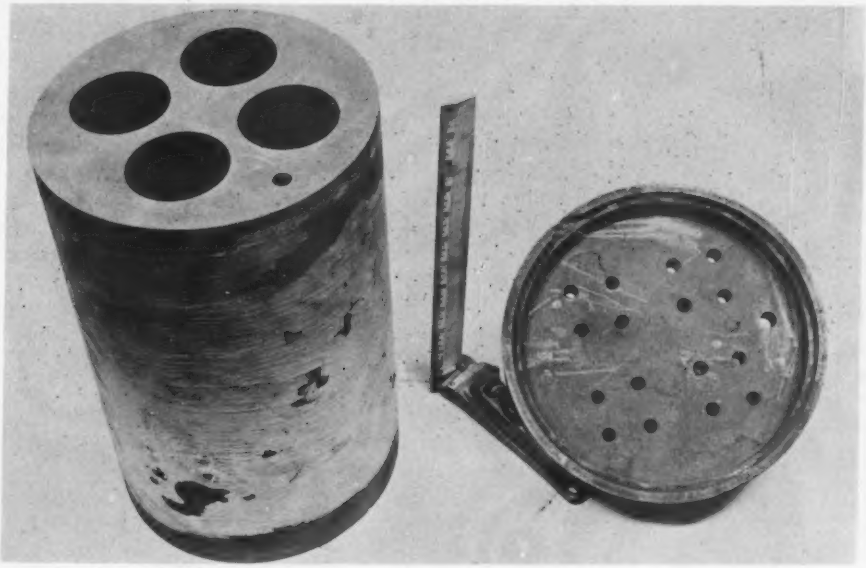

Fig. 1 — Typical graphite billet (left) with pouring basin (right).

in neutral salts conventionally used for scale free heat treating of steel.

Molding

As noted, molding materials must be inert to molten uranium. Since there is a number of refractories which are more stable than uranium oxide, the considerations imposed by vacuum melting become of prime importance in selecting a suitable refractory. For example, refractories with high vapor pressures cannot be used. It has been conventional throughout atomic energy facilities to use machined graphite molds coated with various refractories to prevent interaction between the uranium and graphite.

Also, the graphite molding material can be induction heated, in most cases in the same coil which does the melting. This introduces temperature gradients in the mold, and promotes directional solidification to insure a completely sound casting. When graphite molds are used, extreme care must be taken to remove all traces of gas within the graphite. It has been found in practice that graphite molds must be heated to 1300 F (704 C) under vacuum in order to make absolutely certain that no gas porosity will occur within the uranium casting. A typical graphite mold for making bar type castings is shown in Fig. 1.

This type of mold would be set up coaxial with the melting crucible and filled from the top, as shown in Fig. 2. In typical operation, the top of the graphite mold in position is heated to about 2300 F (1260 C), and the bottom of the graphite mold would be in the range of 1300-1400 F (704-760 C). This produces excellent directional solidification and gives a maximum yield of metal cast. Design of graphite molds for simple shape castings is therefore relatively simple. A riser volume of 20 per cent is used, and a shrinkage allowance of 1.8 to 2.2 per cent is made depending on the degree of restraint caused by the graphite mold.

A satisfactory mold wash consists of a thin zirconite base wash, which is then covered with a sec-

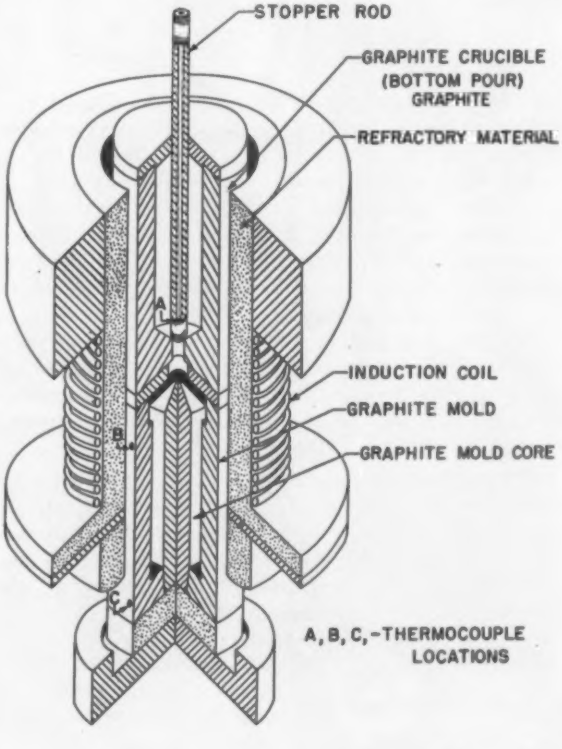

Fig. 2 — Uranium bottom pour induction melting and casting furnace used at Watertown Arsenal.

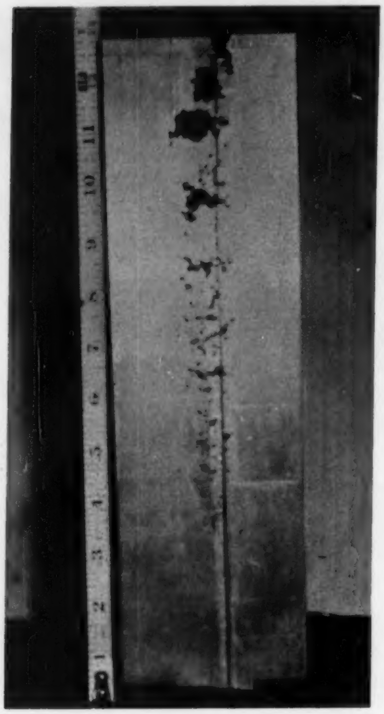

Fig. 3 — 3⅝-in. diameter uranium, 8 per cent molybdenum alloy. This casting was originally 18 in. long. Centerline shrinkage extended almost throughout the casting.

ond coating of fine mullite. At Watertown Arsenal both washes are normally put on by brushing rather than spraying. After being coated, the molds are packed in an oven at 400 F (260 C) for at least 2 hr. This procedure results in fine casting finishes, which will show the brush marks on the mold coating and will result in negligible carbon pickup from the mold.

Ceramic Molds

Sintered ceramic molds have been used, and generally are more economical in use than machined graphite molds. Better dimensional control is obtained with ceramic molds, and preheating prior to pouring is not necessary providing the ceramic molds have been fired at high temperature. No attempt at heating ceramic molds for the establishment of thermal gradients would normally be made; therefore, careful gating and risering techniques must be used. The uranium 8 per cent molybdenum alloy, which is the most important of the structural uranium cast alloys, shows a shrinkage comparable to that which will be obtained in a low carbon steel casting.

An example demonstrating the type of shrinkage which occurs is shown in Fig. 3, which is a saw cut section through a 3⅝-in. diameter billet approximately 18 in. high. It was bottom gated. The sintered zircon mold used was of the following composition for each 100 lb batch:

80 lb zircon sand
20 lb zircon flour
1500 cc water
500 cc phosphoric acid (C.P.)
712 grams aluminum hydroxide

It can be seen from examination of Fig. 3 that the zircon mold caused freezing from the outside diameter in, and little feeding along the length of the billet was obtained. This shrinkage is fairly comparable to what would have been obtained with a low carbon steel casting cast in a zircon mold. Castings made in the zircon mold show a fine surface finish and have no evidence of any chemical reaction. Another mold material used at Watertown Arsenal is commonly a process which has been widely described in the literature.[1]

The refractory material used for uranium is a fine mullite. Other aspects of the molding procedure with this mold material are well described in the referenced article. Castings produced in this manner have exceptionally fine surface finish and excellent dimensional reproducibility. Figure 4 shows some small projectile castings which have been cast to close tolerances in the molding process. These little projectiles, being machined from bar stock, are currently replacing tungsten base alloys at a great reduction in cost. Figure 5 shows another test casting poured in this molding material.

The pattern shrinkage allowance, which should be made in using this process is about one per cent, similar to that for steel. Here again the uranium casting will show fine detail and fine marks left in the mold during the molding process.

Melting and Pouring

As outlined previously, molten uranium will rapidly form carbides, oxides, nitrides and hydrides. This extreme chemical reactivity precludes the melting of uranium in air, in certain oxide crucibles and in carbon or carbide crucibles, unless a protective wash is applied to these materials. The most frequently used crucible material is graphite. The desired crucible is normally machined from large blocks and given a coating of a thin, adherent stable oxide. For convenience, at Watertown Arsenal the same wash is used for molds as for crucibles.

A creamy solution of zirconite in water is thinly spread over the crucible and allowed to dry. Following this, a second coat of a proprietary coating is brushed on and baked out at 400 F (260 C) for 2 hr. Properly applied, this coating will adhere to the crucible during melting, and carbon pickup is insignificant if not undetectable. Graphite crucibles can be used for tilt pouring or bottom pouring. A typical resultant analysis is:

Heat	Mo	Ti	C	O	H	N	Si	Fe
Desired, %	8/8.5	1/1.2	<0.015	<0.006	<0.0002	<0.0002	<0.02	<0.060
E-76, %	8.20	1.00	0.0115	0.0034	0.00016	0.0013	0.006	0.0084

Figure 2 shows a conventional crucible-mold setup for melting and casting in graphite. Naturally, little induction stirring is obtained when a graphite crucible is used, but the degassing action of the high vacuum will cause adequate stirring for homogeniza-

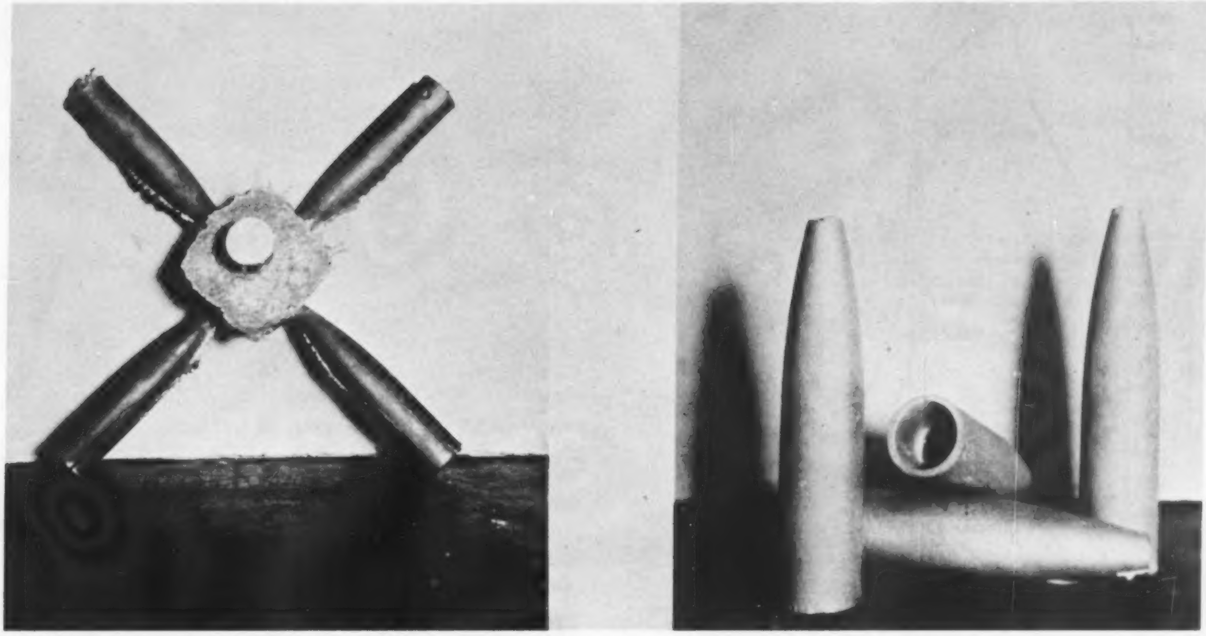

Fig. 4 — Uranium projectile casting made by patented process[1]. Castings attached to sprue-riser are at left, and cleaned projectiles are at right.

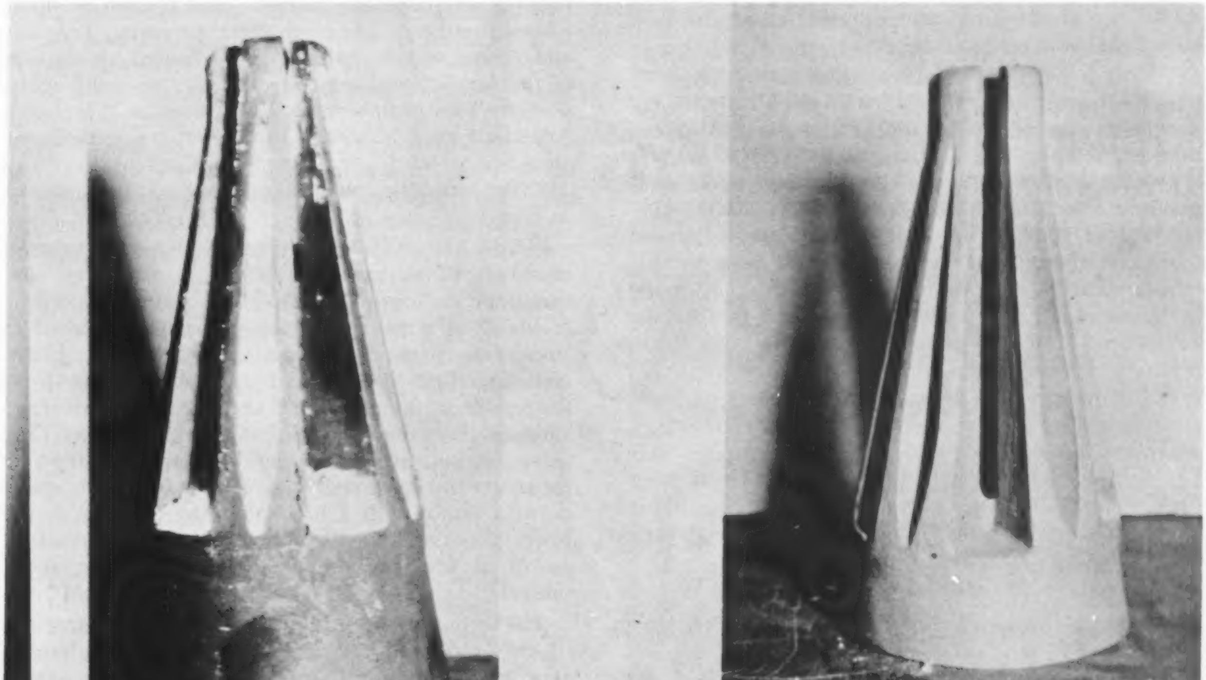

Fig. 5 — As-cast uranium castings shown at left, and after cleaning and sand blasting at right.

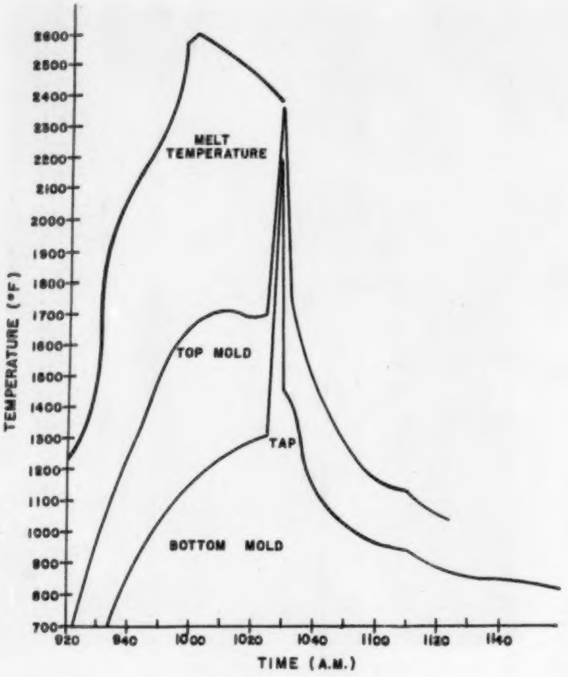

Fig. 6 — Thermal history of important portions of conventional melting and casting used shown in Fig. 2.

tion if the alloys are held for about 5 min at 2550 F (1399 C) or above. It should be noted in Fig. 2, that three temperatures are recorded throughout the melting and casting cycle. The melt temperature *A*, the top of the mold temperature *B* and the bottom of the mold temperature *C*.

To make perfectly sound castings in this type of unit, temperature of *C* is 1300 F-1400 F (704-760 C), *B* is high enough so the top of the mold is at the liquidus temperature about 2350 F (1288 C) and *C* is 100-200 F (38-94 C) above the liquidus. These temperature conditions have been found satisfactory for sections of ¾ to 8 in. and for a wide variety of shapes. A thermal history of a typical heat in this casting unit is shown in Fig. 6. The casting made in this instance was a bushing about 6 in. in outside diameter 14 in. long, with a ¾-in. wall thickness.

It should be noted that the power input and relative positions of the crucible and mold have been controlled so that the charge has been melted and homogenized by the time the proper gradients have been established in the mold. Also noteworthy is the rapid solidification of the casting even though the mold was thoroughly preheated.

MgO Crucibles

Sintered MgO crucibles have been used for small heats, but for larger heats rammed MgO lining is satisfactory for melting heats to be tilt poured. Tilt poured heats at Watertown Arsenal have been poured from both graphite and rammed MgO. One disadvantage of tilt pouring is that highly radioactive particles are dispersed throughout the vacuum chamber, and stringent health physics precautions must be observed. Use of a bottom pour setup, as shown in Fig. 2, will give the minimum amount of radio activity in the vacuum chamber.

Induction heating of the crucible and charge (and often mold) for melting in vacuum is the universal practice. The equipment is similar to air induction melting equipment, except that the field voltage is limited to 400 volts as higher voltages cause "corona" type of electrical discharge in vacuum as well as arcing. The power supply used at Watertown Arsenal is a 600 kw motor-generator set of 960 cycle frequency. The power requirements for melting uranium are not great due to its low specific heat and the low melting point.

The furnaces, crucibles and molds are housed in a chamber which can normally be evacuated to a pressure of about one micron. One micron is about 1.3 millionths of an atmosphere pressure. The size and design of the chamber is predicated by the size of the furnace and quantity and size of molds to be poured. Two chambers are being used at Watertown Arsenal. Figure 7 shows a small, 4 ft inside diameter chamber, which is used to melt and cast up to 300 lb of alloy in the conventional casting unit shown in Fig. 2.

Figure 8 shows the 8 ft inside diameter vacuum chamber, which can be used either for large conventional casting or for the tilt pouring of ceramic molds. While melting is always begun at less than 10 microns, pressure increases up to 200 microns have not caused any significant change in mechanical properties of soundness of the castings. Two stage vacuum pumping is used for both chambers. That is, a large mechanical roughing pump is used to lower the pressure to about 1000 microns at which point a pump with a high pumping capacity at the lower pressures is activated to assist the mechanical pump in lowering the chamber pressure to about one micron.

These pumps are called booster pumps and are of two types—oil and mechanical. The mechanical type has a more uniform pumping capacity over a wider range of pressures than does the oil type. Therefore, the mechanical pump is recommended for melting chambers which may be exposed to large uncertain gas loads under vacuum. The furnace shown in Fig. 8 has adequate vacuum pumping capacity consisting of a 780 cfm roughing pump with an 8000 cfm blower-booster pump. The total volume of the chamber is about 450 cu ft. The stainless

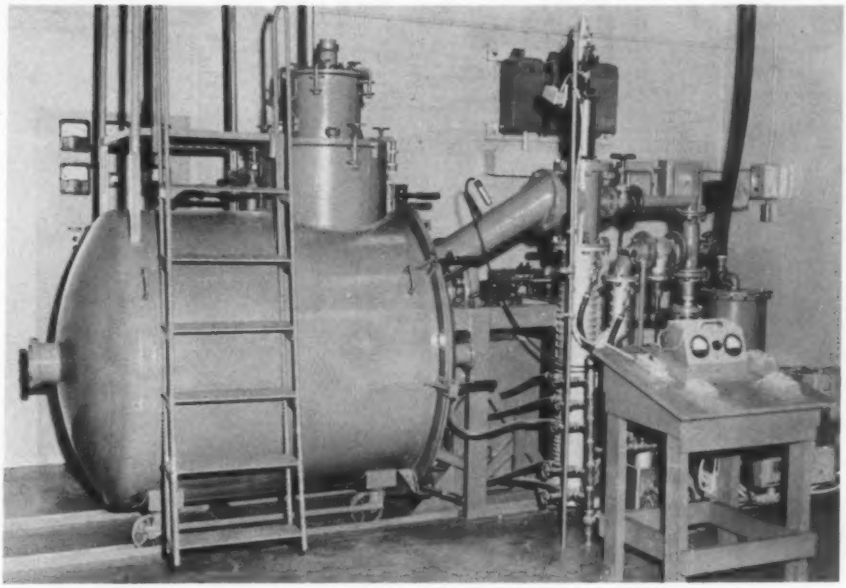

Fig. 7 — Vacuum chamber and pumping system used in conventional graphite crucible mold arrangement shown in Fig. 2.

steel shell is water cooled as is conventional in vacuum melting furnaces.

Inspection

In addition to normal dimensional inspections, the quality of uranium alloy castings may be controlled by most nondestructive test methods, except those which are designed for ferromagnetic materials. Dye check inspection of all uranium parts made at Watertown Arsenal is routine. In addition, full use of radiography is made, although long exposure times at high voltages are required.

Figure 9 is an x-ray of the riser and upper section of a bushing casting made in a graphite mold. It shows a sound casting-riser interface, with the shrinkage appearing as a white cloudy area confined to the upper part of the riser. Figure 10 shows two radiographs at different densities of the casting shown in Fig. 5. The riser section has been removed and the casting is of excellent soundness.

Careful chemical analysis is essential to adequate quality control of uranium castings. In particular, the mechanical properties and ductile-brittle transition temperature is sensitive to hydrogen content. The hydrogen content is normally less than two ppm in the as-cast part. However, heating in saltpots and air can raise this as high as 6.3 ppm. This is extremely important, because pickup of as little as 2.5 ppm of hydrogen can reduce the room temperature ductility to a fraction of its original value.

Another valuable aid in establishing a casting practice is macro-etching. This will show general grain structure as well as areas of microporosity which will not be detected by x-ray. A macro-etch of a ½ per cent Mo, ½ per cent Cb, uranium alloy taken from a vertical section of a 6 in. OD, ¾-in. wall thickness bushing is shown in Fig. 11. This grain structure does not give adequate ductility. Figure 12 shows a horizontal section of a 2 per cent Mo bushing casting which has a fine grain size. Macro-etches of 8 per cent Mo alloys show a finer grain structure

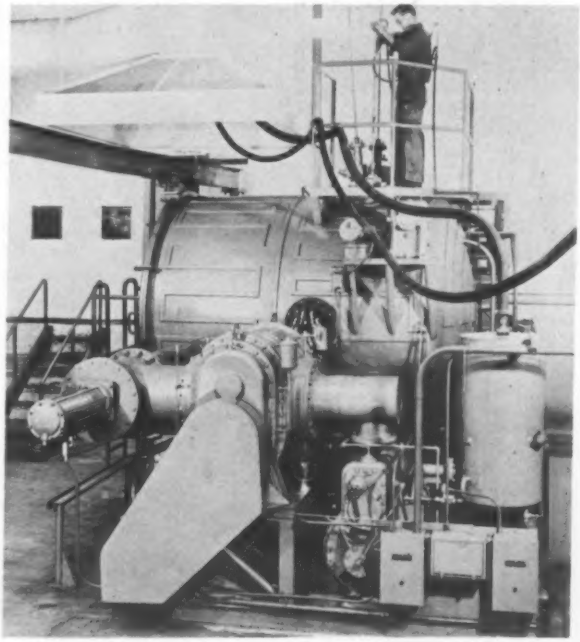

Fig. 8 — Vacuum system for 2200 lb uranium vacuum melting furnace which can be used for conventional bottom pouring or tilt pouring ladles. Chamber is of 8 ft inside diameter and 9 ft long. Melting power is 300 kw.

Fig. 9 — Radiograph of riser and upper part of casting described in text. Shrinkage is confined to the riser section at the top of photo. Casting is sound.

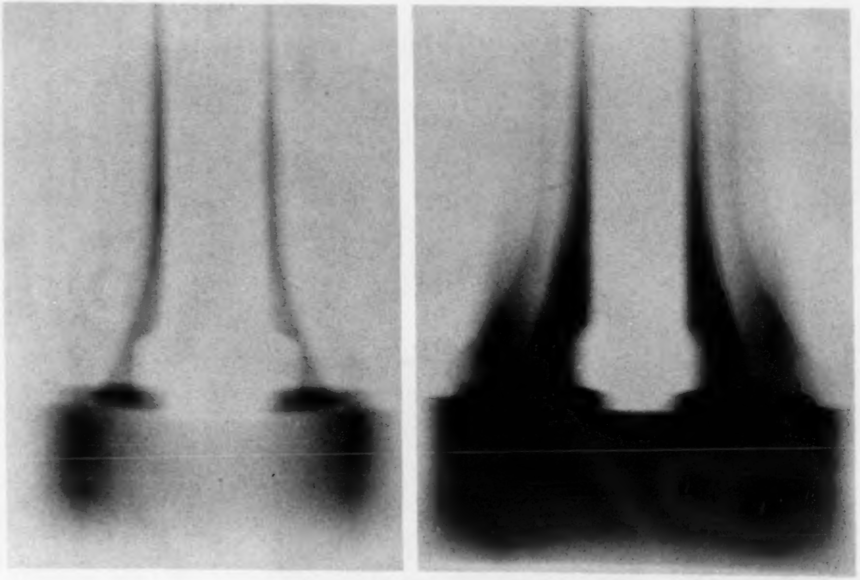

Fig. 10 — Radiographs of rather complicated uranium casting shown in Fig. 5. Films are of different density in order to obtain proper accuracy in the thin and thicker sections of casting.

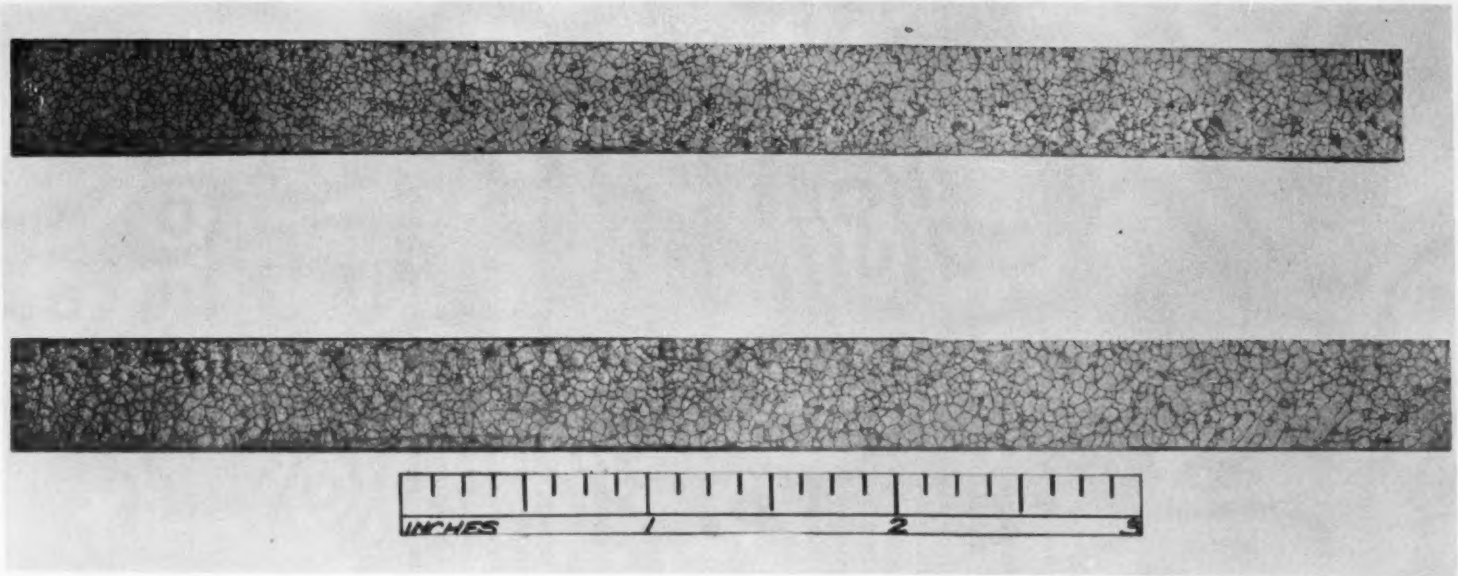

Fig. 11 — Macro-etch of a uranium ½ per cent molybdenum, ½ per cent columbium alloy. Section at top is bottom portion of casting, and section at bottom is upper portion of casting. Note that grain size is large and nonuniform.

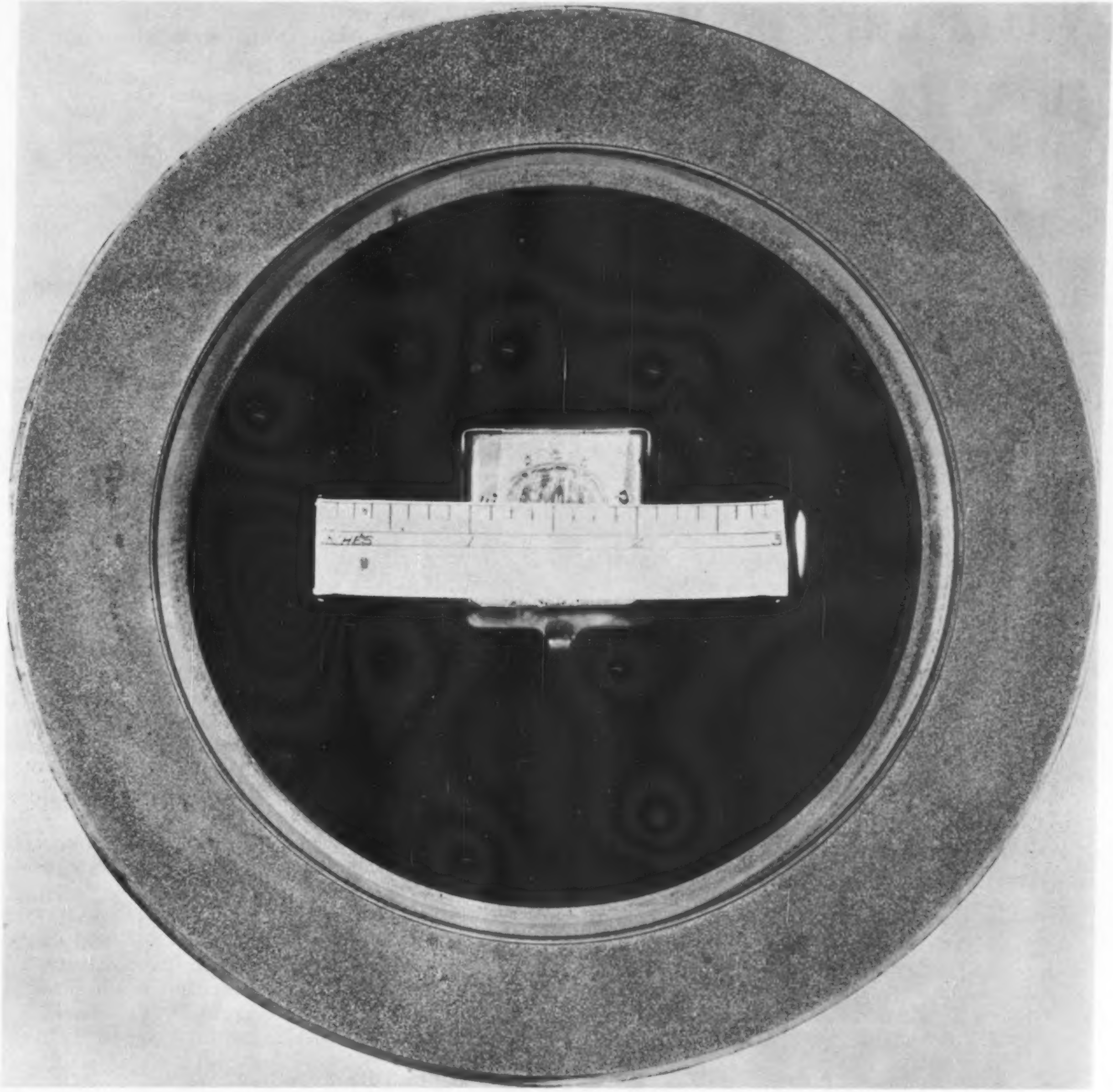

Fig. 12 — Macro-etch of horizontal slice through a vertically cast bushing in uranium, 2 per cent molybdenum alloy. The grain size is fine and will yield good ductility for this analysis. Reduced slightly in reproduction.

than that of Fig. 12. This type of structure will give the optimum properties outlined below for heat treated castings.

PHYSICAL METALLURGY

The physical metallurgy of uranium alloys is wonderously complicated, and there are many excellent references on the subject.[2,3] At present, the alloys of prime interest are those which have high strength and corrosion resistance. The alloys which satisfy this requirement are metastable gamma phase alloys. Additions of molybdenum and columbium will make gamma uranium (body centered cubic structure) stable at normal temperatures much in the same manner that chromium will make austenite in steel stable at normal temperatures.

Thus, while the equilibrium phase diagram Fig. 13 shows alpha and delta phases at room temperatures, one finds that, in the range of about 7 to 12 per cent Mo, the high temperature gamma phase is stable. This one phase alloy has excellent corrosion resistance to mildly corrosive media—far better than mild steel. Unprotected, machined castings will stay bright and shiny for periods in excess of one year. However, if these metastable gamma alloys are slowly cooled during casting they will contain some alpha and delta phases, and must be reheat treated in order to make them ductile and fully corrosion resistant.

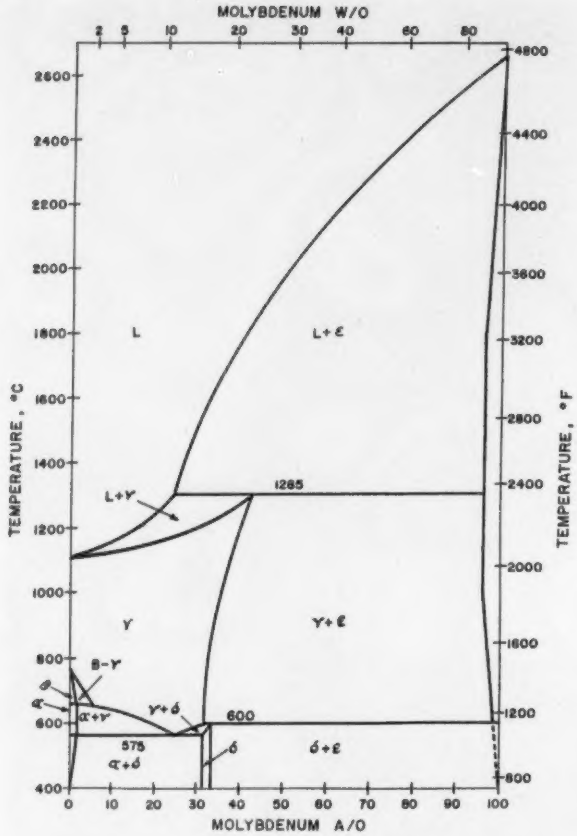

Fig. 13 — Uranium-molybdenum equilibrium phase diagram. Under nonequilibrium cooling the gamma phase is stable at room and slightly elevated temperatures from 7 to 12 weight per cent molybdenum.

In normal production at Watertown Arsenal the 8 per cent Mo castings are heated to 1600-1650 F (871-899 C) in vacuum for several hours, depending on thickness and oil quenched. The castings heat treated in this manner will yield these mechanical properties consistently:

Y.S., 0.1 per cent offset, psi	130-135,000
T.S., psi	130-140,000
Elongation, per cent	15-17
Reduction of Area, per cent	40-50
Charpy impact at −40 F, ft-lb	3-8

A short stress relief treatment at 950 F (510 C) can be given the castings without lowering ductility. However, holding for more than a few hours will cause the tensile strength to drop to about 100,000 psi, and cause the ductility to drop to zero.

For the future, the possibilities in uranium alloys are manifold—there are alloys which form martensitic phases,[4] there are alloys which can be age hardened and modifications of the metastable gamma alloys will be of higher strength than now available. In alloy development programs at Watertown Arsenal tensile strengths in excess of 200,000 psi have been obtained. Alloys of this strength do not have as good ductility or corrosion resistance as is desirable, so it can be concluded that the physical metallurgy of uranium alloys will be a fruitful field for study in the years to come.

SUMMARY

The processing techniques for making structural uranium alloy castings at Watertown Arsenal have been described. Important aspects of the practice are:

1. Uranium must be melted in vacuum or inert gas. Vacuum melting is preferred to insure proper quality.
2. Mold materials must be free of minute traces of absorbed gases, i.e., graphite must be heated to 1300 F (704 C) under high vacuum in order to eliminate gas porosity.
3. Uranium can form a low melting eutectic if it contacts bare iron or steel at temperatures in excess of 1340 F (727 C). It dissolves carbon and reacts with some common refractories so that short melting cycles and pouring at the lowest temperatures should be used to reduce contamination.
4. Careful chemical analysis of heats must be made in order that good ductility can be assured. It has been shown that hydrogen in as little amounts as 2.5 ppm can reduce ductility to a small fraction of its original value.
5. Vacuum heat treating is required to assure good ductility, because uranium can dissolve hydrogen from air and molten "neutral" salts at the normal heat treating temperatures encountered and the castings will be drastically embrittled thereby.
6. Adequate health physics precautions such as the use of film badges, monitoring radiation and good housekeeping are required for foundry operations regardless of whether or not the uranium is natural, enriched or depleted. This is required because the radioactively hot isotopes and daughter products segregate during melting, and if airborne can cause a level of radioactivity in the vacuum chamber far above the maximum allowable exposure. Castings made of alloys of depleted (D-238) uranium will show a small level of radioactivity, which can be ignored for all practical purposes.

For current engineering applications requiring a maximum density or great gamma ray absorption, combined with a high strength and good corrosion resistance uranium base alloy castings are not only economically competitive with other materials, but are indeed unique in their ability to satisfy these requirements.

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LOW MELTING ALLOYS FOR PATTERN SHOP USE

by O. J. Seeds

ABSTRACT

Use of bismuth (low temperature melting) alloys in making of duplicate patterns for matchplate construction is discussed. Factors of economy in processing and speed in construction are important considerations in pattern shop uses of these materials. In addition to pattern fabrication methods are described for use of low melting metals applied with a spray gun — to coat wood patterns to increase wear and prevent warpage, to construct metal shell patterns for core boxes and dryers and to make metal faced plaster reinforced molds for plastic patterns. Bismuth alloys provide a quick, easy method for fastening patterns in matchplates, producing patterns compensated for shrinkage, altering or repairing both patterns and matchplates and for salvaging worn core boxes and for checking core prints and core boxes.

INTRODUCTION

Metal master working patterns are frequently used in match plate production for various reasons, such as greater durability and ease of removal from wet molds.

Wet molds (plaster) offer considerable resistance to removal of wooden patterns, and those having weak thin sections requiring draw screws for withdrawal may be broken. Metal patterns are most readily withdrawn from plaster molds.

A variety of metals is available for making master patterns and they are found roughly in two classes — high temperature melting metals and low temperature melting alloys.

High temperature melting metals, including aluminum, antimonial-lead, copper, zinc, tin, white metal, etc., have several major disadvantages in production of duplicate patterns:

1. They shrink from $\frac{3}{64}$-in. – $\frac{9}{64}$-in./ft, and this factor requires time for computation of allowances to offset this shrinkage.
2. High melting temperatures require special melting and pouring equipment.
3. They cannot be poured into wood molds without damaging the mold, and they cannot be poured into plaster molds which are not fully dehydrated without danger of steam blowing.
4. Shrinking pattern metals pull away from molds on solidification, and thus fine detail is poorly reproduced resulting in need of chasing and cleaning, which is extra work.

Low melting alloys for pattern fabrication and those most frequently used are listed in the table. The outstanding characteristics which commend the bismuth alloys (bismuth is the principal common component) for pattern shop uses are:

1. Nonshrinkage.
2. Low pouring temperature – some can be poured below boiling temperature of water.
3. Expansion or growth – some of the bismuth alloys grow over a period of several hundred hours as much as $\frac{1}{16}$-in./ft, and this factor can be put to good use.

Compositions are given in the table to enable anyone to make them up as desired. However, it is generally more economical to use the proprietary commercially available alloys as they carry a guarantee of composition and can be relied upon for uniformity of performance.

LOW MELTING ALLOYS USED IN PATTERNMAKING

Alloy No.	Melting Temp., F (C)	Melting Range, F (C)	Bismuth, %	Lead, %	Tin, %	Cadmium, %
1*	158 (70)	–	50.0	26.7	13.3	10.0
2	–	158-190 (70-88)	42.5	37.7	11.3	8.5
3*	255 (124)	–	55.5	44.5	–	–
4	–	281-338 (138-170)	40.0	–	60.0	–
5*	281 (138)	–	58.0	–	42.0	–

*Eutectic compositions.

The reasons low melting alloys are ideal for pattern metals are:

1. Nonshrinking. They do not shrink as other types of pattern metals, but actually expand when freezing pushing into fine mold detail assuring perfect reproductions.
2. These metals cast well in sand, plaster, wood or other materials, and much time is saved because less hand chasing and clean up are required.

O. J. SEEDS is Mgr. Alloy Dept., Cerro Sales Corp., New York.

3. Thin sections are easily cast because of high fluidity of the metals when fully liquid, especially alloys 1, 3 and 5 in the table. Two and 4 are also fully fluid above their liquidus points, but it will be noted these points are much higher than those of the eutectic composition.
4. Low melting and pouring temperatures (about one half of other pattern metals) result in faster melting with fuel savings.
5. Simple melting equipment will serve. An ordinary iron pan or ladle over a gas flame or electric hot plate is satisfactory for melting.
6. Gates can be cast integrally with patterns, and since they are easily soldered to brass runner time and money are saved in master pattern work (Fig. 1).
7. Low melting point metal patterns are ready for use immediately after solidification, requiring no curing time.
8. Full salvageability. After low melt alloy patterns have served their purpose at the foundry they are returned to melting pot for reuse indefinitely (Fig. 2).

FABRICATING METAL PATTERNS

A suggested technique for fabricating metal patterns with alloy 3 in sand molds is:

1. Dust wood pattern with lycopodium for parting.
2. Face pattern with about ¼-in. Windsor Locks sand, after which fill flask with a fine Albany sand.

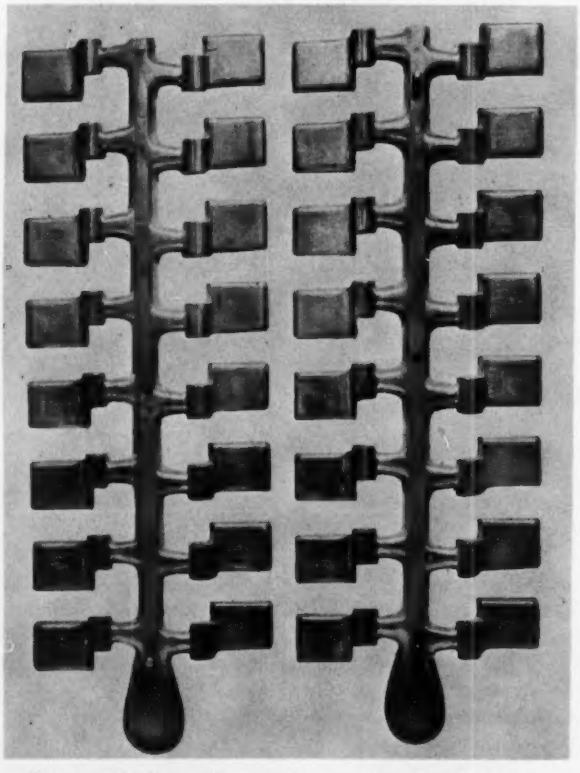


Fig. 1 — Fusible alloy patterns with integrally cast runner and gates.

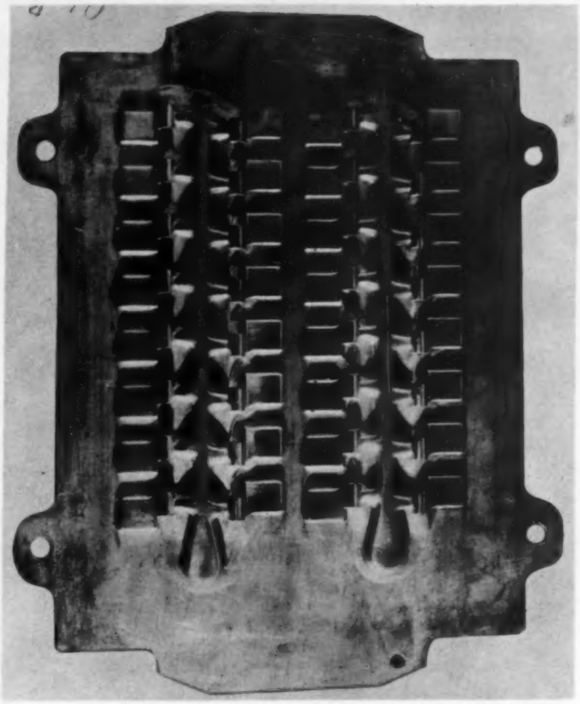
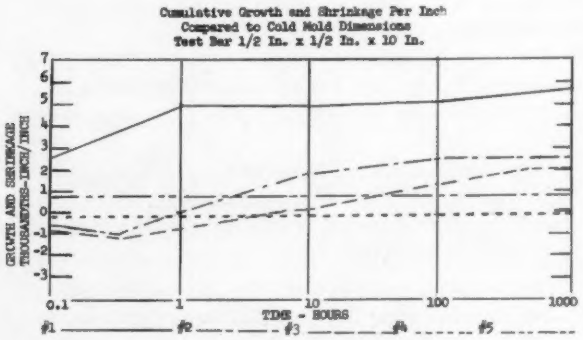


Fig. 2 — Aluminum matchplate molded patterns, alloy patterns returned to pattern shop for remelting.

3. Heavy solid molded castings should be poured with heavy riser on opposite side from gate or runner leading into casting.
4. Some experimenting with pouring temperature may be necessary, and a thermometer should always be used to check metal temperature when pour is made. Long, thin castings require about 310 F (154 C) pouring temperature. Heavy, thick solid castings require about 270 F (132 C) for best results.



For plaster molds use a mixture of one part dental plaster and one part powdered silica. Using alloys 3, 4 or 5 will require the plaster mold to be thoroughly oven dried (1 and 2 can be used in partially dried plaster molds). Oven dry molds should be dusted with thin layer of table salt, sodium chloride or calcium chloride to any moisture. Remove salt before casting.

When soldering gate to runner, tin runner with ordinary tin-lead (50/50) solder. With reduced heat in soldering iron join gates to runner with a solder of alloy 3 one part and 50-50 solder one part. Zinc, ammonium chloride flux is satisfactory. Alloy 3 is the choice of a number of patternmakers, because it expands enough to offset metal removed by steel wool clean up after sand casting.

Higher dimensional accuracy of patterns is obtained by use of alloys 4 and 5 when casting in plaster molds. Better surface finishes are produced when casting in plaster molds if the mold walls are kept as thin as possible to accelerate cooling. The quicker solidification occurs, the better the surface finish will be.

Wood molds are sometimes convenient or desirable to use for casting patterns. With low melting alloys, such as alloy 3, no special treatment of a wood mold is necessary, except to remove any finish which may have been applied. There is no danger of discoloration or damage to the wood. Low melt alloy castings are as smooth as the wood itself, and any wood grain visible on surface of castings is easily removed with fine steel wool or a light polish on a cotton buffing wheel.

Core Box and Dryer Patterns

A rapid, accurate method for making core box and dryer patterns utilizes alloy 2, and results in great savings in manufacturing cost as well as superior castings.

The method was worked out as a solution to the problem of producing master shell patterns of wood having uniform wall thickness. Wood shell patterns of $\frac{3}{8}$-in. wall thickness, with involved curved sections are practically impossible to make.

The method uses a metal sprayer or gun designed for use with bismuth alloys. The procedure is:

1. A core plug is made of wood and mounted on a plywood or masonite board (Fig. 3).
2. Graphite or powdered mica is brushed and polished on the pattern (plug) and board. This is a separator.
3. Alloy 2 is sprayed on all surfaces of pattern and top of board to $\frac{3}{16}$-in. thickness (Fig. 4).
4. Ribs are added to give reinforcement, bosses and dowels are added for blow holes (Fig. 5).

Larger core boxes are made by spraying a light shell of low melting alloy approximately $\frac{1}{64}$-in. thick. A layer of cheese cloth cut to fit the surface of the sprayed core plug is bonded to the surface with shellac. Added thickness is obtained by applying layers of burlap which have been dipped in creamy plaster of paris, and carefully smoothing over the surface. When plaster is dry, add reinforcement ribs and feet to the shell pattern.

Such patterns are usually strong enough to be molded. However, it is recommended to use the plug as a ram up block to support them while ramming.

Because the low melting alloy surface is in direct contact with the core plug there is a direct transfer, and no loss of dimension occurs. Smooth surfaces, curvatures, sharp corners and angles are all reproduced with highest accuracy with minimum of time and

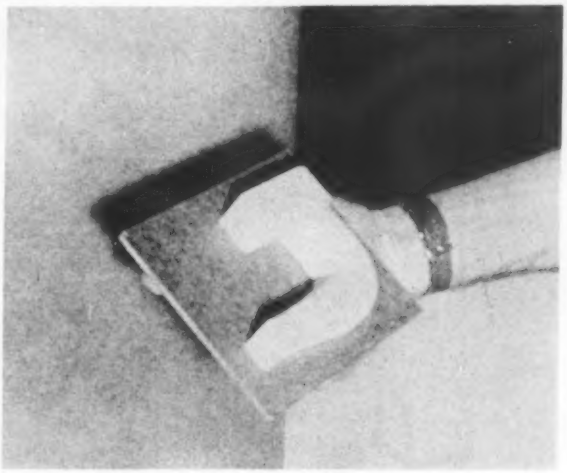


Fig. 3 — Core plug mounted for spraying with alloy 2.

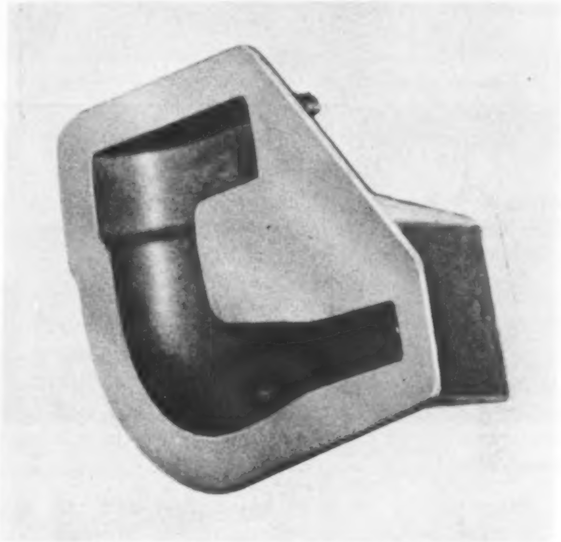


Fig. 4 — Sprayed shell pattern accurately reproduces contour, dimensions and finish of plug.

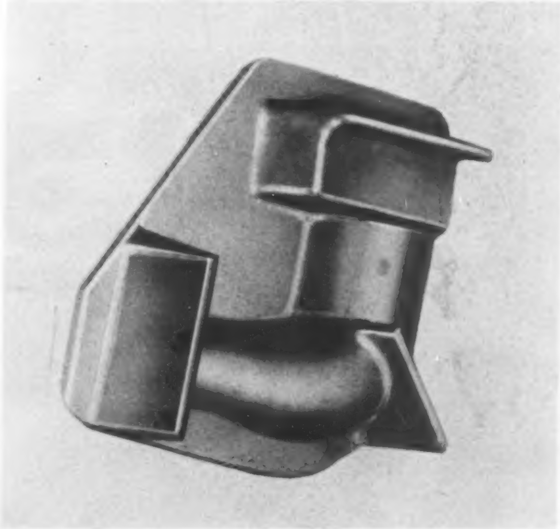
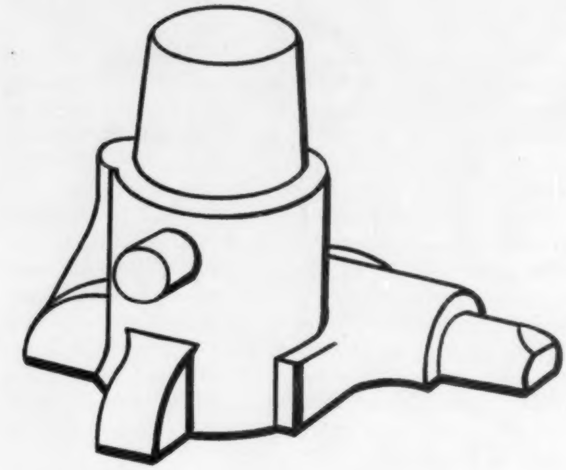


Fig. 5 — Showing bottom of pattern with supporting feet of wood glued on after spraying.

Fig. 6 — Solid pattern to be altered.



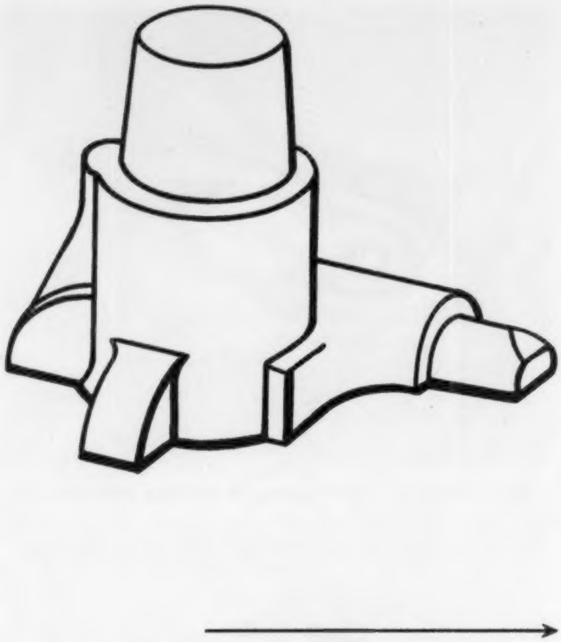


Fig. 7 — Boss added (held with brad and wax).

equipment. Uniform thickness shell patterns can be constructed in this manner at a fraction of time and cost required to produce them in wood.

Shrinkage Added to an Exact Size Pattern Produces Patterns Compensated for Shrinkage

Occasionally it is necessary to reproduce a metal casting for which no pattern or blueprint exists. To make a pattern or several duplicates, enlarged to offset the shrinkage of the casting metal, use the following procedure:

1. Place casting on mold board, flask and ram sand to make a mold. Plaster can be used if desired.
2. The first known user of this idea chose alloy 2, melted it in a double boiler and cast it in the sand mold. After aging 4 hr it was noted the casting was 0.004 in./in. larger than original casting. While the growth chart shows only 0.0018 in./in. growth in test bar ($\frac{1}{2}$ in. x $\frac{1}{2}$ in. x 10 in.) in 4 hr, the larger amount can be accounted for by rapping to withdraw casting. Also, other shapes and heavier masses may give different results, so the chart and tabular data should be used only as a guide.

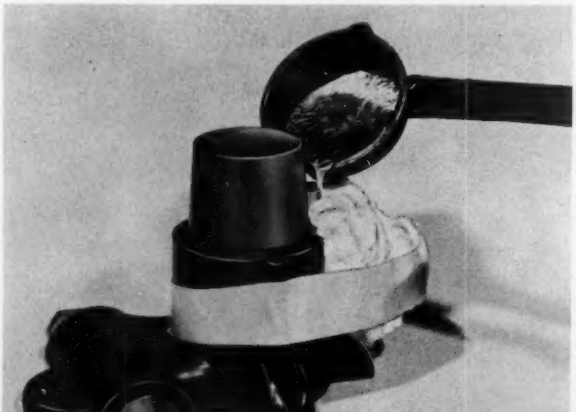


Fig. 8 — Pouring fusible alloy 5 to fill loose piece impression and section of pattern.

The alloy casting aged 4 hr is placed on the mold board and a new sand or plaster mold is made, and casting and aging process repeated.

Again, a third mold and casting are made and the casting is aged 4 hr.

From this third enlargement a plaster mold is made, and the required number of castings taken from it. Final castings aged 4 hr will be found to have increased by $\frac{3}{16}$-in./ft, the amount needed to equal shrinkage of casting metal.

Altering Solid Pattern With Loose Piece

When altering a straight draw solid pattern by addition of a boss, for example, complete rebuilding to a split pattern can be avoided by making a loose piece in a low melting alloy (Fig. 6).

First make the wood boss and brad it to pattern (Fig. 7). Fillet with wax. Take a plaster impression of the boss and adjacent section of pattern (Fig. 8). When plaster is set, remove and cut out dovetail section as shown in Fig. 9. Fasten plaster impression over the chiselled out section and pour alloy 5 to fill the cavity.

When alloy has solidified, remove plaster and trim the loose piece to give proper clearance (Fig. 10). The alloy expands slightly when it freezes, hence it will need relieving to facilitate removal when drawing from mold. Drill blind hole in back of loose piece so

wire hook can be used to withdraw loose piece from mold.

Metallizing Wood Patterns and Core Boxes

Warpage and loosening of glued joints and fillets can be minimized if not prevented completely by coating wood patterns with low melting metal.

It is easy to apply low melting metal 2 with a sprayer designed especially for service with these metals.

Wood patterns are given two coats of shellac, and when the second coat is tacky spraying begins. Any desired thickness of metal may be applied, but about 0.003 in. is considered sufficient. Advantages of this procedure, in addition to minimizing warpage, are — increases life of pattern to almost that of metal patterns, permits easy repair of nicks and dents, alterations can be done readily, metal can be cut by ordinary wood working tools and respraying to cover new surfaces joins smoothly to old coating.

Matchplates Repaired or Altered

Changes, alterations and repairs of matchplates can be quickly and inexpensively made with low melt alloys (Fig. 11).

To change shape or size of one or a series of patterns on a matchplate, build up and carve to exact shape and size of one pattern with wax or clay (Fig. 12). Take a plaster impression of this built up pattern (Fig. 13). Remove plaster when set and mark off margin of built up area with scriber. Rout the marked off area at least $\frac{1}{8}$-in. deep (Fig. 14). Drill hole through this depression to back of plate. Replace plaster over the routed depression and pour alloy 5 into the hole (Fig. 15). Alloy will flow against plaster, picking up detail of the alteration and will lock into the depression, making a perfect in-lay on the plate (Fig. 16). Much time can be saved in repairing damage plastic patterns by use of low melting alloy and this technique.

Assume that only one of several identical patterns is to be repaired. Since all patterns are alike, take plaster impression of corresponding area on adjacent pattern. While waiting for plaster to set, have low melting alloy in process. When plaster has set, remove from

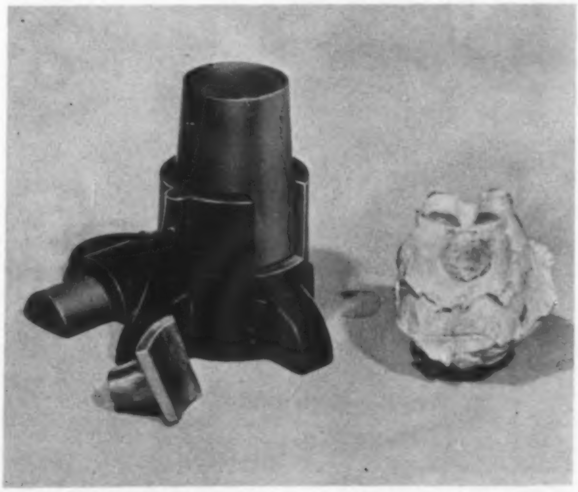


Fig. 9 — Dovetail section under boss location chiselled out. Plaster impression seen at right.

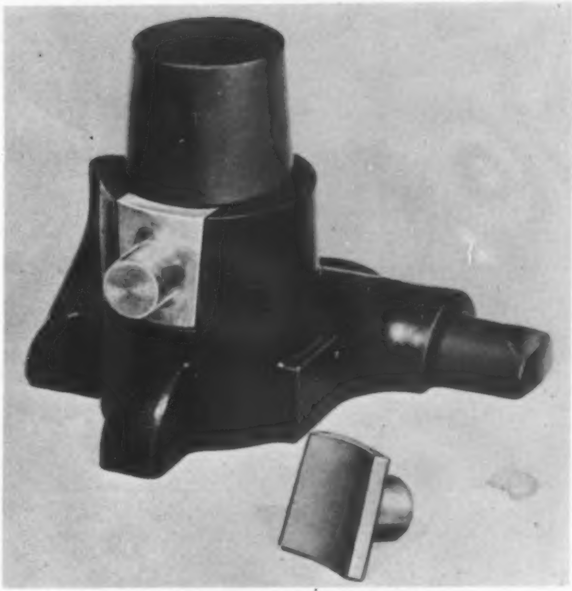


Fig. 10 — Finished loose piece in position on pattern.

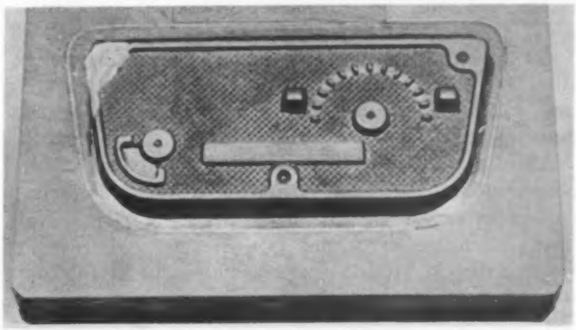


Fig. 11 — Broken corner of matchplate pattern to be repaired.

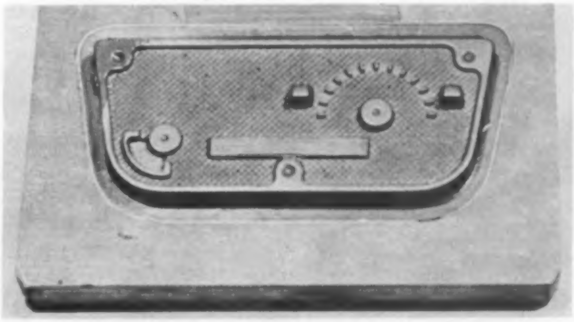


Fig. 12 — Corner rebuilt with wax.

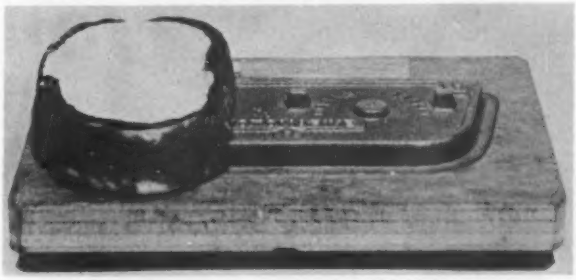


Fig. 13 — Plaster impression being taken of rebuilt section.

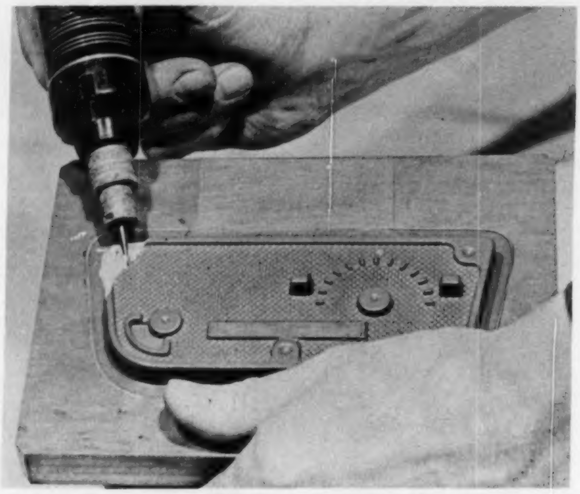


Fig. 14 — Broken section being undercut to anchor fusible alloy. Pouring hole drilled through to other side.

plate and rout area under impression. Eliminate feather edges and drill hole through routed area to other side of plate. Replace plaster and pour molten alloy 5. Plastics require careful measuring and mixing of ingredients plus several hours curing time after pouring.

Also, plaster must be thoroughly dry to assure proper cure. Plastic has limited shelf and pot life, and any excess must be discarded. Low melting metals have indefinite shelf and pot life, require no curing and thus save both time and money by giving tools ready to use immediately after solidification.

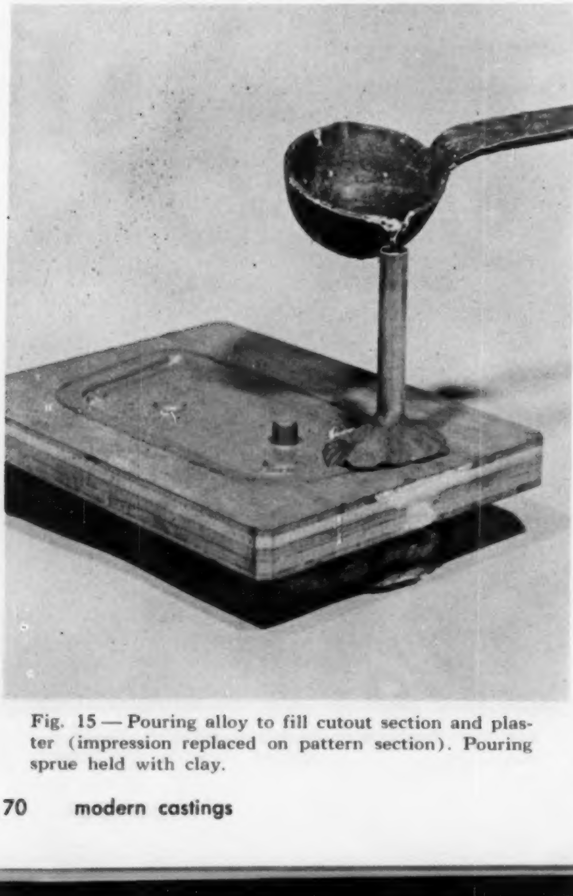


Fig. 15 — Pouring alloy to fill cutout section and plaster (impression replaced on pattern section). Pouring sprue held with clay.

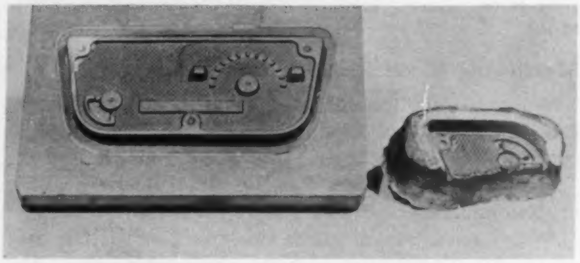


Fig. 16 — Plaster impression removed showing perfect inlaid repair, pattern ready for immediate use.

Aluminum Matchplates Raised Letters

By employing same technique, omission of lettering on master pattern can be easily corrected on completed matchplate.

Glue or shellac desired letters on one pattern and take a plaster impression. When plaster has set, remove from plate. Scribe area around lettering, remove letters and rout the area at least 1/8-in. deep with under cut sides. Drill hole to other side of plate through routed area. Repeat routing of corresponding area for remainder of patterns. Replace plaster over area and pour full with alloy 5. Repeat for balance of patterns. This is possibly the quickest method known for this kind of alteration.

Wood Ram-Up Core Boxes Metal Linings

Ram-up cores are useful in molding patterns which have pockets or sections otherwise difficult to draw (Fig. 17). Making core boxes to fit this type of core is sometimes costly, because the core must not be too tight nor too loose. Adjustments are time consuming. A rapid and accurate method of core box making is:

Make well or dam of clay around pattern section to be cored. Taper sides of dam to form section of core, which will be held in green sand mold. Fill pattern section and well with plaster of paris. When set, remove plaster and trim down to loose fit in the pat-

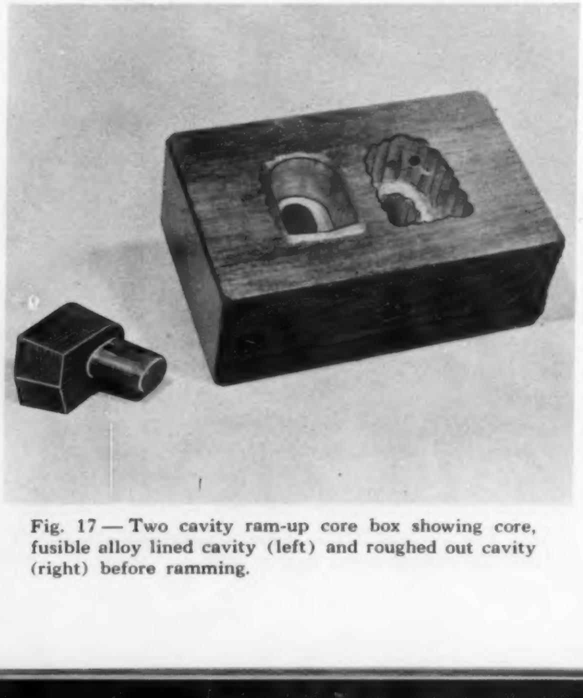


Fig. 17 — Two cavity ram-up core box showing core, fusible alloy lined cavity (left) and roughed out cavity (right) before ramming.

tern. Chop out a cavity in a block of pine or mahogany 1/8-in. larger all around than plaster core pattern. This cavity should be fairly rough and under cut at various places. Drill hole through cavity to outside. Fasten pattern with brad, glue or shellac to a flat surface.

Place block with cavity centralized over pattern. Weight down block and pour in alloy 5. As illustrated in Fig. 18, an extension sprue is to be used to assure a pressure head which helps to pick up all detail on pattern.

Low melting alloys are poor conductors and will solidify slowly in wood and plaster molds, therefore sufficient time for freezing must be allowed — 2, 3, 5 min or more, as needed.

Worn Core Boxes Salvaged

It is no longer necessary to discard worn or damaged wood core boxes. An inexpensive procedure has been developed to restore damaged wood core boxes.

Build a pouring box around the core box. Fill core cavity and pouring box and screen off. When set, remove plaster core and smooth it to perfection by carving or sanding any projections due to dents or nicks in core box.

Using a burr, rotary file or other cutting tool, cut away about 1/8-in. of inside surface of core box cavity. Drill one or more holes (1/4-in.) through core box wall to the cavity.

Replace core on box and clamp or tape together. Warm up core and box before pouring. About 250 F (121 C) for wood — 280 F (138 C) for metal box (core should be baked to eliminate moisture). Through extension sprue pour alloy 3.

Epoxy Resin Patterns Fabrication

Epoxy resins have grown rapidly in popularity among patternmakers recently. To offset some of the extra time required in fabrication of patterns from these materials as well as increasing mold life, a method for using low melting alloy has been developed.

While plaster molds can be used for pouring and curing epoxies they must be dried out first and this requires much time, depending on thickness and volume of plaster.

Fig. 18 — Ram-up core box in position over core model. High pouring sprue is optional but its use assures complete fill.

Fig. 19 — Spraying master pattern with thin coat of low melting alloy.

Fig. 20 — Plaster is poured to back up metal coating.

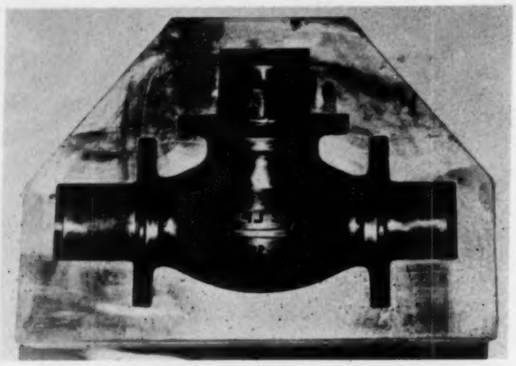


Fig. 21 — Metal faced mold ready for use, dehydration of plaster unnecessary.

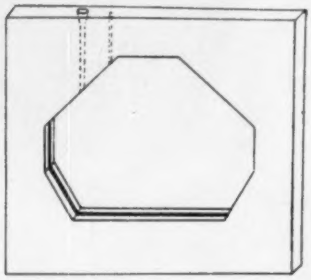


Fig. 22 — Matchplate with pouring hole, vent holes and groove in side opening ready for insertion in pattern.

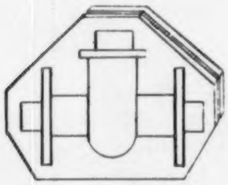


Fig. 23 — Pattern with matching groove ready for insertion.

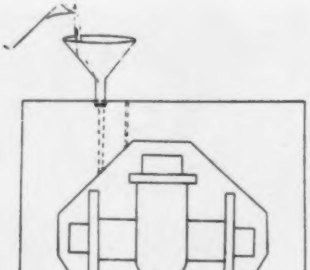


Fig. 24 — Fusible alloy poured to lock pattern in matchplate.

By applying a thin layer of low melting alloy 2 to surfaces of pattern before pouring plaster much time can be saved. That is, the mold will be ready for use as soon as the plaster has set, and no drying out is necessary.

The pattern is fastened down in the same manner as for pouring plaster. After coating pattern with graphite, wax or other parting medium and polishing vigorously, spray on a coating of alloy 2 to a thickness of $\frac{1}{16}$-in. to $\frac{1}{8}$-in. (Fig. 19). Apply coat of quick dry lacquer or shellac to sprayed surface, and when dry pour plaster to fill flask which has been placed around pattern (Fig. 20).

Immediately after plaster has set, pattern may be removed from mold and it is ready for use (Fig. 21). Besides economy in time of construction such metal faced molds offer the benefit of much longer life than unfaced plaster. From 10 to 20 casts can be obtained from a metal faced mold, which is considerably more than can be obtained from regular plaster molds.

A proprietary process for anchoring patterns in matchplates is a novel method of mounting plastic patterns which eliminates nails or screws for fastening. The use of this process has effected appreciable savings in matchplate production there and elsewhere.

Patterns are made of plastic in the usual way in plaster molds and cured. An opening of same shape and size of pattern for loose fit is cut in the wood or metal matchplate. Outside of pattern and inside of hole are grooved at the midpoint and vent and pouring holes drilled to groove in plate (Fig. 22). Pattern is inserted in opening and joint taped to prevent leakage (Fig. 23). Fusible alloy 1 is poured to completely fill groove (Fig. 24). When solid, the metal spline maintains positive anchorage.

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CENTRIFUGALLY CAST STEEL CYLINDERS RAPID GAS HEATING TECHNIQUES

by A. Ayvazian

ABSTRACT

An investigation was carried out to study the effects of rapid gas heat treating of centrifugally cast 4330 thick walled steel cylinders in the 150,000-180,000 psi yield strength range. The cylinders were heated for hardening and tempering in specially designed rapid heating gas furnaces. Temperatures used were higher than those ordinarily employed in conventional practice to compensate for the shorter holding time commensurate with the furnace performance capability. Similar cylinders were also heat treated by conventional techniques. Cylinders heat treated by both methods were subjected to metallurgical examinations, and a comparison made of the properties indicated favorable results.

INTRODUCTION

The success of many Ordnance applications is attributed to a combination of certain mechanical properties, mainly, ductility and impact properties. Any methods or processes which could improve these properties of Ordnance employed steels would be a considerable accomplishment. Recently, the never ending search for such practices led to the investigation of a high speed gas heating process. In essence, the concept of this process is to subject the charge in the furnace to temperatures in excess of the final desired temperature for a short time, whereby an appreciable thermal gradient is attained between the surface and center of the workpiece.

This is followed by an equalization period of time in order to heat the material uniformly throughout its cross-section. The introduction of this process into the heat treating field as an accepted mode of through heating is not a recent innovation, since the theory and process have been in existence since World War II. However, improved heat processing, attributed primarily to the development of recent ceramic burners, has renewed interest in the application of rapid gas heating. Also, successful employment of rapid heating in the metal forming industry warranted that this manner of heating steel be utilized in order to observe the potentialities of such a process for heat treating of Ordnance steel components.

Exploring the characteristics of this heating technique, it is found that reduction of time and the employment of elevated temperature are the predominant factors which distinguish this method of heating from conventional methods. Heating rates from one to 5 min/in. of thickness are anticipated for plain carbon, low and medium alloyed steel in comparison to the conventionally accepted rates of 30 to 60 min/in. of thickness.

This paper describes the first phase of an investigation conducted to study the feasibility of utilizing this process by comparing the mechanical properties obtained from the rapid gas heat treatments vs. conventional gas heat treatments of centrifugally cast 4330 thick walled steel cylinders in the 150,000-180,000 psi yield strength range.

PROCEDURE

Test Casting

The test castings selected for this investigation were five actual 90mm centrifugally cast 4330 steel full length gun tubes. Similar castings were being produced and heat treated by conventional methods to meet stringent mechanical properties required by gun tube specifications. It was conceived that, if these test cylinders, heat treated by the rapid heating process, produced mechanical properties comparable to those being obtained by the conventionally treated cylinders, then this would be one criterion by which this process could be evaluated.

The cylinders to be tested were produced from

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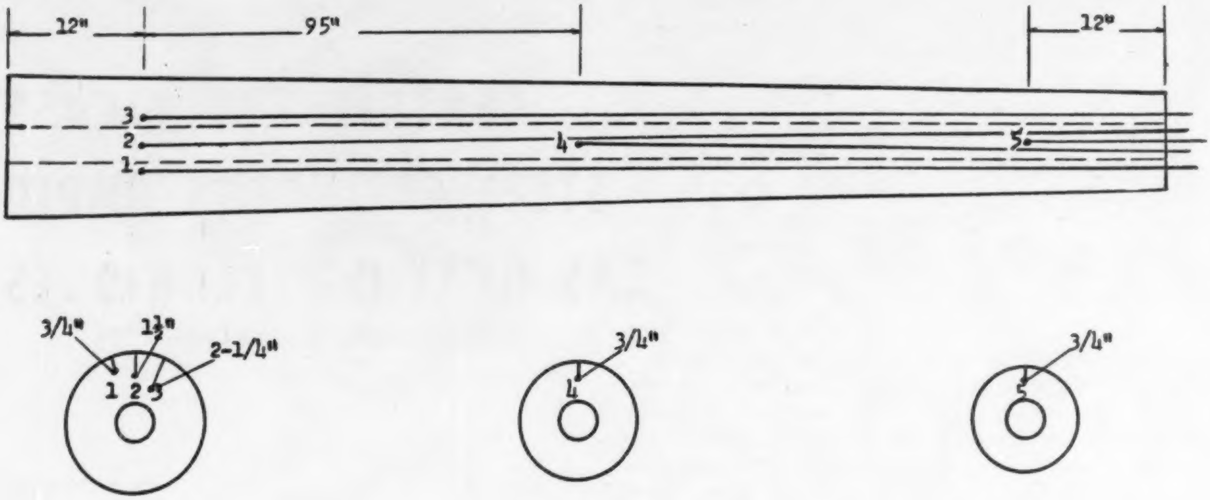


Fig. 1 — Schematic showing location and depth of thermocouples.

different heats with final typical chemical composition of:

C	Mn	P	S	Si	Ni	Cr	Mo	V
0.285	0.64	0.011	0.019	0.24	2.24	0.84	0.47	0.22

Preparation and Heat Treatment of Test Specimens

The cylinders, numbered 5, 6, 7, 8 and 9, were normalized at 1750 F (954 C) prior to the tests. After the normalize, they were machined so that the dimensions were approximately 17 ft long with outside diameter of 8½-in. at one end tapering down to about 5½-in. outside diameter at the other end. Each cylinder had a bore of about 2½-in. Chromel-alumel thermocouples were attached to each cylinder, as shown in Fig. 1. Three thermocouples were located one foot from the heaviest end, and penetrated into the surface at distances of ¾, 1½ and 2¼-in. A fourth thermocouple was placed at midlength, ¾-in. into the surface and a fifth thermocouple was placed one ft from the other end, also ¾-in. into the surface. These five thermocouples were attached to a multiple-point recorder which recorded the temperature distribution in the cylinder as it was heated.

Prior to heating the test cylinders, preliminary tests were conducted with surplus specimens in order to arrive at some procedure which would produce yield strength values within the 150,000-180,000 psi range. From these tests, the most applicable treatments were selected for the five test cylinders. The hardening treatment in all five specimens was similar and consisted of vertically placing the specimens which were to be treated, one at a time, into a specially designed vertical furnace with 36 ceramic burners.

The furnace, which contained two controlled zones, was operating at 2300 F (1260 C) at the bottom zone

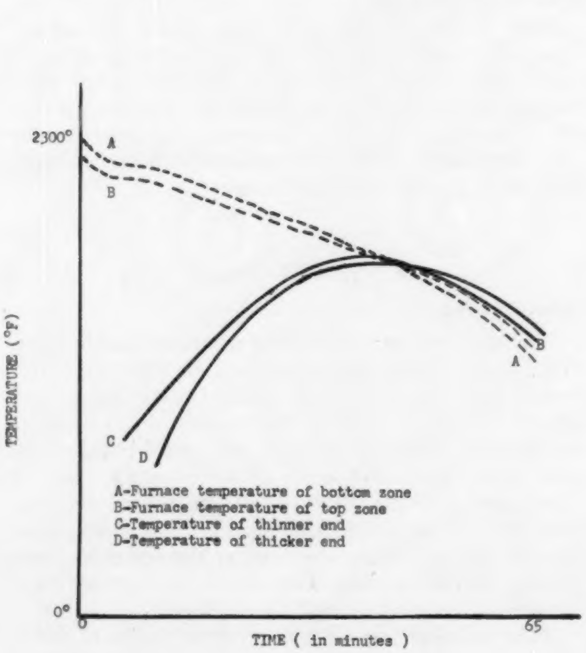


Fig. 2 — Schematic graph showing general shape of curves representing austenitizing cycle of cylinder vs. furnace temperature.

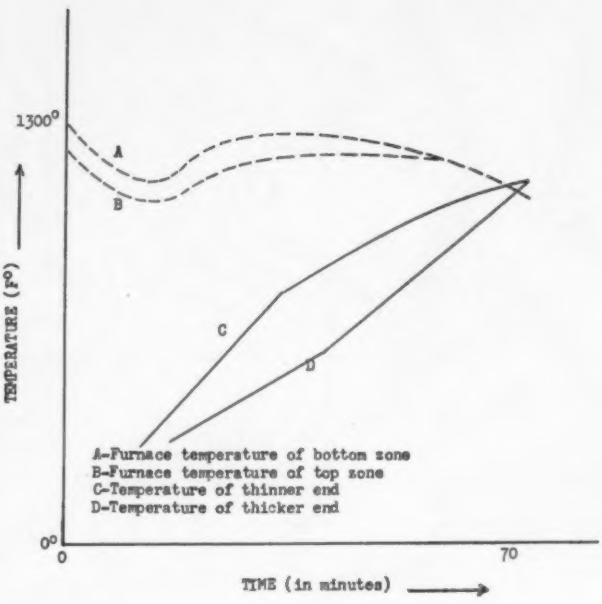


Fig. 3 — Schematic graph showing general shape of curves representing tempering cycle of cylinders vs. furnace temperature.

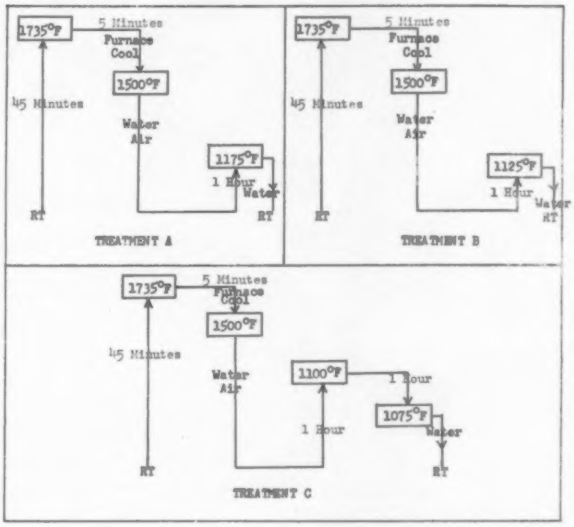


Fig. 4 — Schematic showing treatments employed in final tests.

and 2100 F (1143 C) at the top zone when the specimen was placed into the furnace. The differential in furnace temperature was to compensate for the taper in the cylinder. As the temperature of the specimen gradually increased, the furnace temperature was progressively lowered (Fig. 2). The specimen was periodically rotated in the furnace to allow for uniform heating. In 45 min both furnace and specimen reached 1735 F (946 C), the austenitizing temperature.

The burners were shut and the specimen allowed to cool to 1500 F (810 C) for 15 min prior to water quenching. The quenching consisted of completely submerging into cold water for 2 min, followed by a tapered quench for 1½ to 2 min. Subsequently, the cylinder was cooled in water to near room temperature after a 4 min equalization period in air at around 600 F (316 C). The complete heating and cooling process was followed on the multiple-point recorder.

Tempering Procedure

The technique employed for the tempering was similar to the hardening procedure; however, five slightly different final temperatures were used. The specimen was lowered into another special vertical furnace containing 16 burners. The bottom zone was operating at 1300 F (704 C) and the top zone at 1200 F (649 C). In about 50 min, when both the specimen and the furnace reached a desired temperature (Fig. 3), the burners were shut and the specimen allowed to soak for 10 min prior to water quenching to room temperature. The final temperatures and times are shown in Figs. 4 and 5.

In contrast to the above treatments, the conventional production heat treatment for such cylinders consists of slowly heating to 1600 F (871 C), holding 5 hr, furnace cooling to 1500 F (810 C), holding 2 hr and taper quenching in water until cylinder reaches 600 F (316 C), holding in air for an equalization period prior to cooling in oil to room temperature. The tempering cycle consists of heating to 600 F (316 C), holding 3 hr, raising temperature to 1000 F-1060 F (538-571 C), holding 5½-hr prior to water cooling (Fig. 6).

Mechanical properties of cylinders 1, 2, 3 and 4, heat treated in this manner, are listed in Tables 1 and 3, in order to provide data with which the rapidly heat treated test cylinders can be compared.

Mechanical Tests

Tensile Tests. The testing of the cylinders was performed in accordance with Military Specification

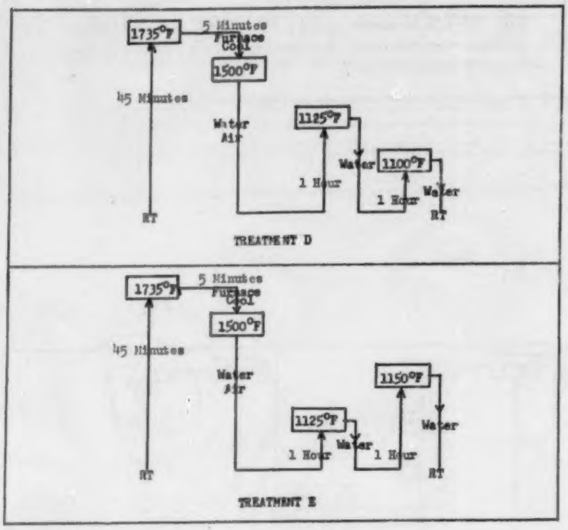
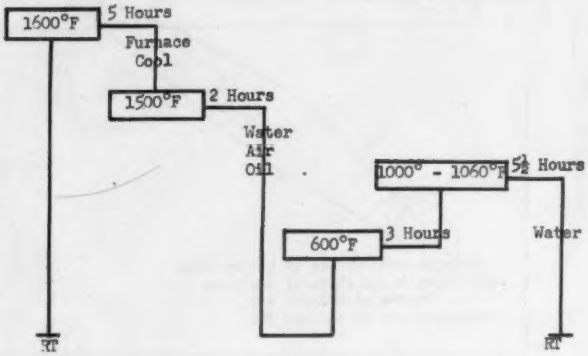


Fig. 5 — (Left) — Schematic showing treatments employed in final tests.

Fig. 6 — (Below) — Schematic representation of conventional heat treatment.



MIL-S-10026 (ORD), Amendment 1 dated Jan. 5, 1950. The tensile bars were standard 0.357 in. taper shank bars with 1.40 in. gage length. Two tensile bars were taken from each of two ¾-in. thick disks, cut perpendicular to the major axis of the test cyclinders. Figure 7 shows the approximate locations from which the disks were cut, and also the locations from which the tensile bars were taken. Tensile strength, yield strength, per cent elongation and per cent reduction in area at 0.1 per cent offset method were obtained from the tensile bars.

Charpy Bars. The Charpy bars were standard 0.394 in. square by 2.156 in. long V-notched impact bars. A total of three bars was taken from each cylinder, two from the thicker end and one from the other end (Fig. 7).

Microstructural Examination

All test cylinders were subjected to microstructural examination after the rapid heat treatments in order to correlate the changes, if any, with those obtained in the microstructure of the conventionally heat treated cylinders. The photomicrographs were taken from two small cube specimens, one cut from an area close to the outer surface and the other from an area close to the bore, as shown in Fig. 7.

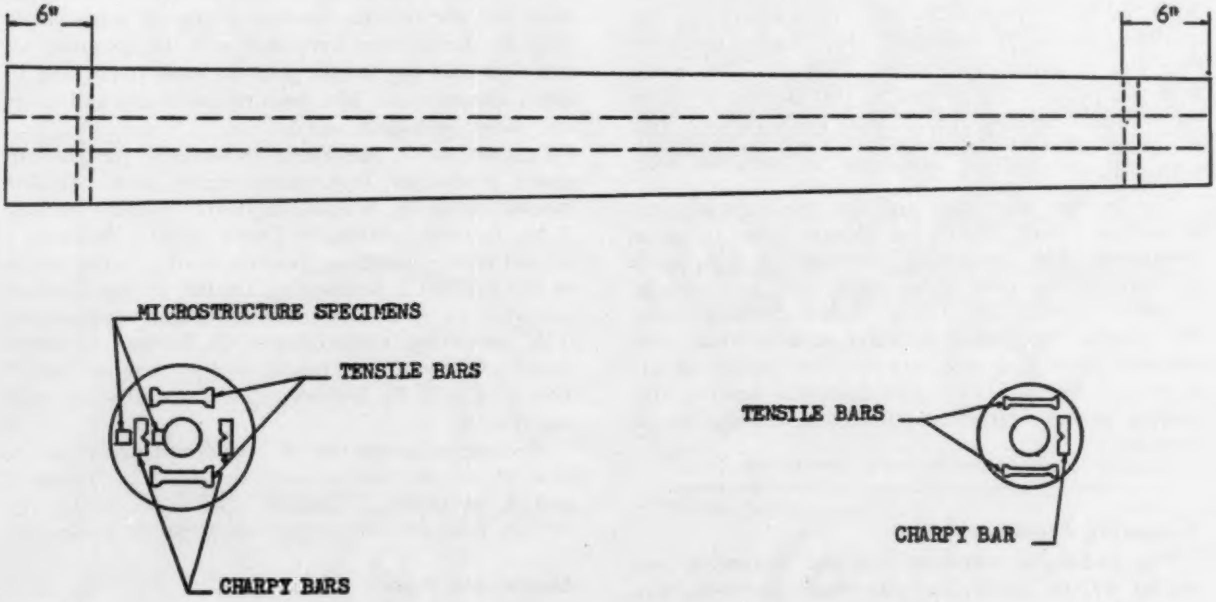


Fig. 7 — Schematic showing location from which test specimens were taken.

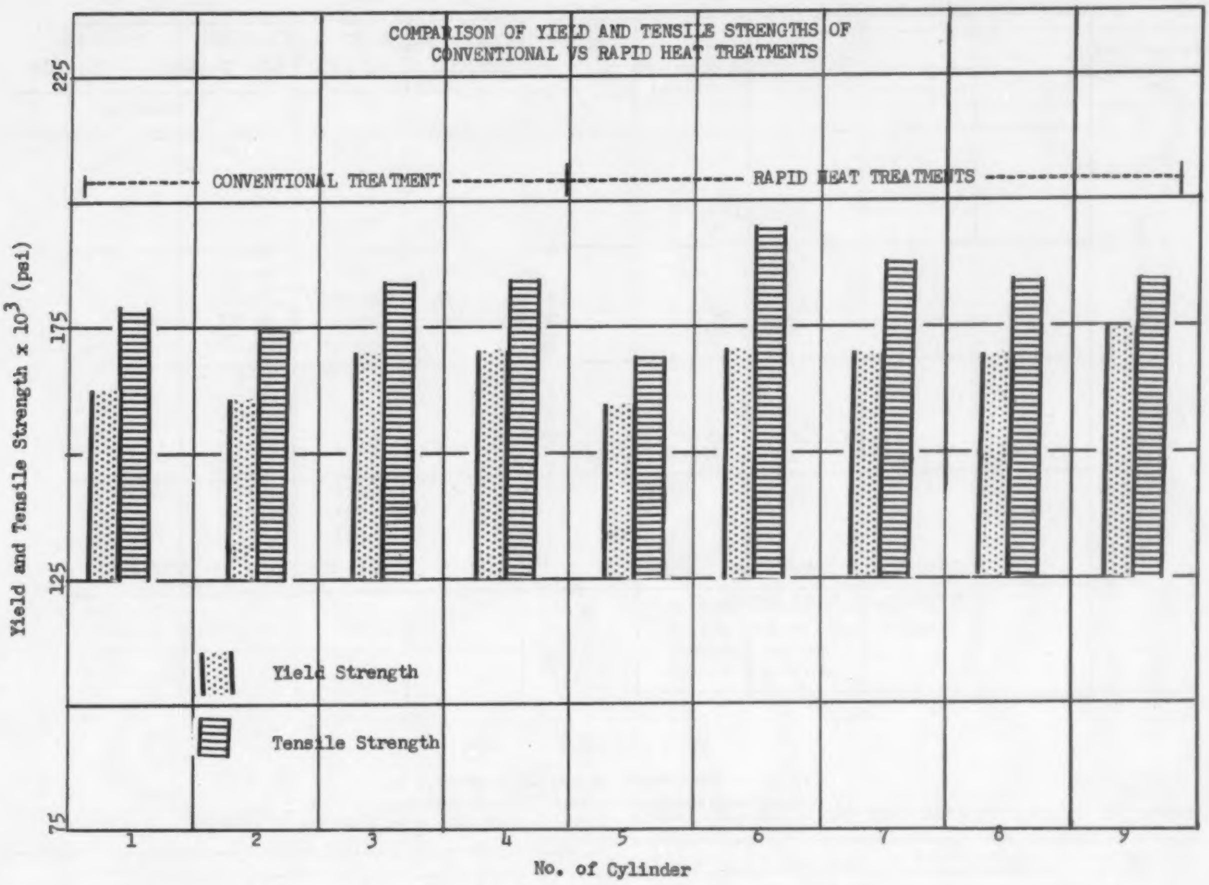


Fig. 8 — Comparison of yield and tensile strengths of conventional vs. rapid heat treatment.

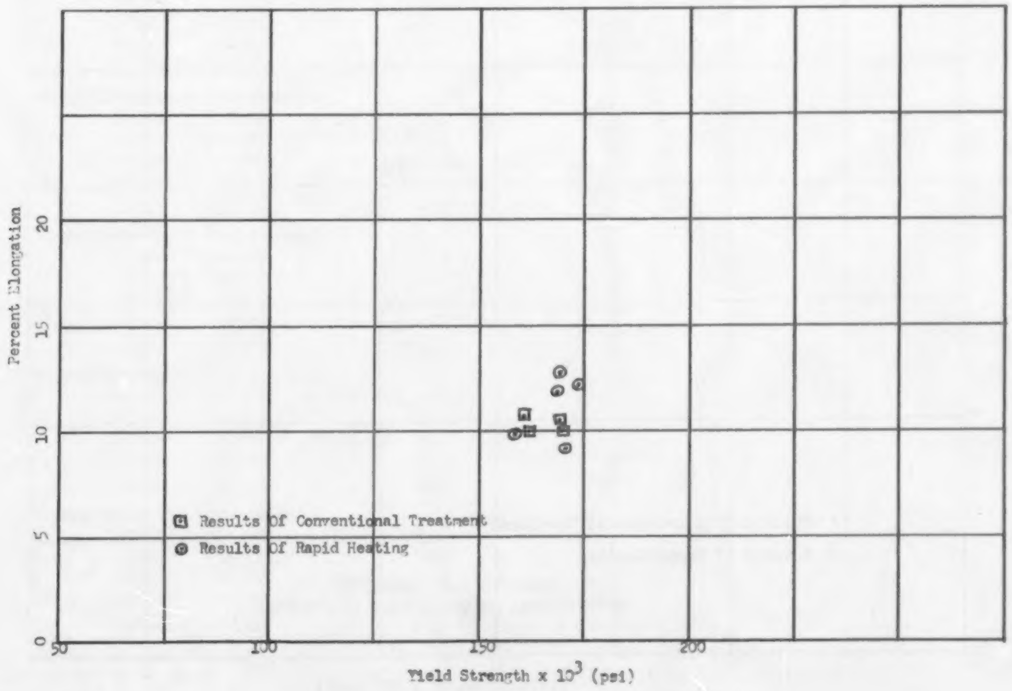


Fig. 9 — Comparison of per cent elongation of conventional vs. rapid heat treatment.

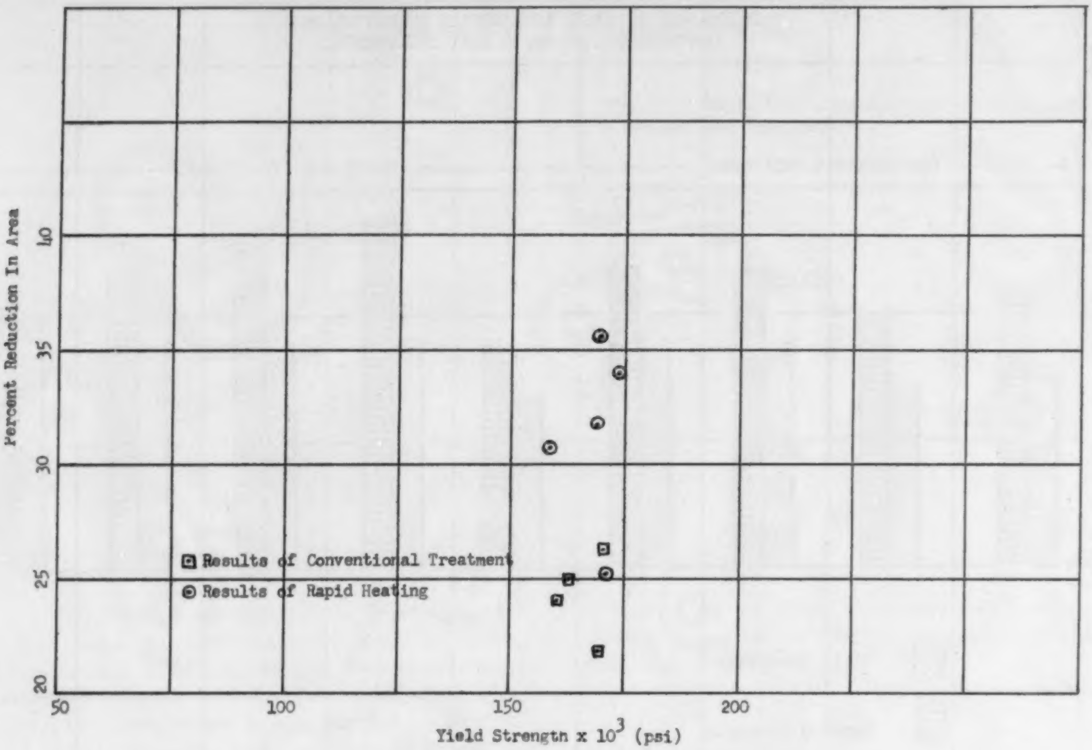


Fig. 10 — Comparison of per cent reduction in area of conventional vs. rapid heat treatment.

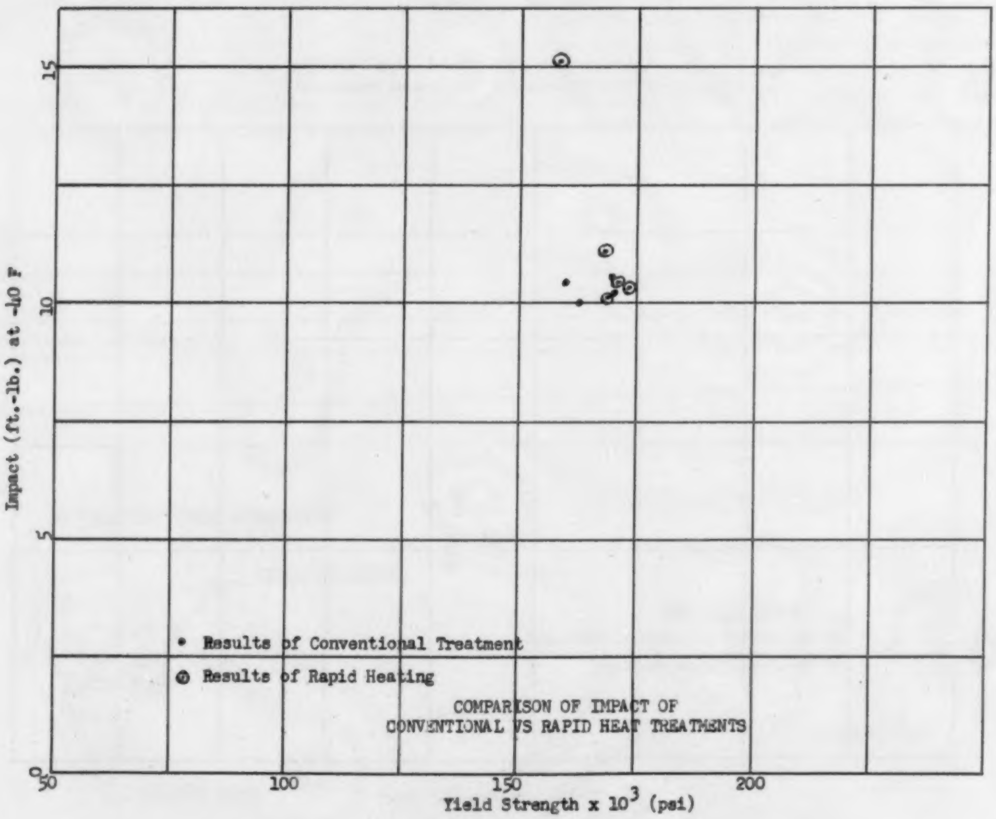


Fig. 11 — Comparison of impact of conventional vs. rapid heat treatment.

TABLE 1 — RESULTS OF TENSILE TESTS CONVENTIONALLY HEAT TREATED CYLINDERS

Cylinder No.	Location of Test Specimen*	Y.S., 0.1 %	T.S.	Elong., %	R.A., %
1	B-6	165,000	180,500	9.3	21.6
	B-12	165,000	181,500	11.4	27.0
	T-12	158,000	173,000	9.3	26.5
Average		162,600	178,300	10.0	25.0
2	B-6	161,500	172,500	13.6	23.1
	B-12	164,000	179,000	10.7	24.6
	T-12	156,500	171,000	7.1	24.6
Average		160,600	174,200	10.7	24.1
3	B-6	171,750	185,000	10.0	19.6
	B-12	165,500	179,000	11.4	24.6
	T-12	170,500	185,500	10.0	21.6
Average		169,275	183,200	10.5	21.9
4	B-6	171,250	185,500	17.9	24.1
	B-12	171,000	184,500	7.1	25.5
	T-12	168,750	180,500	5.0	29.8
Average		170,300	183,500	10.0	26.4

*B — Bottom (thicker end of cylinder).
T — Top (thinner end of cylinder).
6 — o'clock position.
12 — o'clock position.

TABLE 2 — RESULTS OF TENSILE TESTS

Cylinder No.	Location of Test Specimen*	Y.S., 0.1 %	T.S.	Elong., %	R.A., %
		Rapid Heating — Treatment A			
5	B-6	155,500	166,000	3.6	22.6
	B-12	160,100	167,700	9.3	15.1
	T 6	158,500	168,500	12.1	46.5
	T-12	160,000	171,000	13.6	38.5
Average		158,500	168,300	9.7	30.7
		Rapid Heating — Treatment B			
6	B-6	174,500	203,600	7.1	23.1
	B-12	172,000	203,200	4.3	8.2
	T-6	168,000	184,000	12.9	34.5
	T-12	170,000	185,600	12.1	34.9
Average		171,100	194,100	9.1	25.2
		Rapid Heating — Treatment C			
7	B-6	166,000	189,600	11.4	34.0
	B-12	173,500	193,000	11.4	32.2
	T-6	169,500	183,800	14.3	41.5
	T-12	169,500	183,600	13.6	34.5
Average		169,600	187,500	12.7	35.6
		Rapid Heating — Treatment D			
8	B-6	162,500	183,500	12.9	34.0
	B-12	167,000	186,000	12.1	32.6
	T-6	171,000	184,500	10.0	29.4
	T-12	172,000	186,500	12.1	31.2
Average		168,100	185,100	11.8	31.8
		Rapid Heating — Treatment E			
9	B-6	172,500	184,500	10.0	25.5
	B-12	172,000	186,000	12.1	35.8
	T-6	176,000	185,000	12.9	40.2
	T-12	175,500	184,500	13.6	34.5
Average		174,000	185,000	12.2	34.0

*B — Bottom (thicker end of cylinder).
T — Top (thinner end of cylinder).
6 — o'clock position.
12 — o'clock position.

TABLE 3 — RESULTS OF CHARPY TESTS AT −40 F

Cylinder No.	Location of Test Specimens*	Conventional Treatment, Ft-Lb
1	B-3	8
	B-9	—
	T-3	12.0
Average		10.0
Required		12.0
2	B-3	10.5
	B-9	—
	T-3	11.0
Average		10.8
Required		12.0
3	B-3	10.6
	B-9	—
	T-3	11.5
Average		11.1
Required		11.0
4	B-3	10.5
	B-9	—
	T-3	10.0
Average		10.3
Required		10.0

*B—Bottom (thicker end of cylinder).
T—Top (thinner end of cylinder).
3—o'clock position.
9—o'clock position.

TABLE 4 — RESULTS OF CHARPY TESTS AT −40 F

Cylinder No.	Location of Test Specimens*	Rapid Heating Treatments, Ft-Lb A	B	C	D	E
5	B-3	15.9	—	—	—	—
	B-9	14.5	—	—	—	—
	T-3	—	—	—	—	—
	T-9	—	—	—	—	—
Average		15.2				
Required		13.0				
6	B-3	—	8.4	—	—	—
	B-9	—	9.7	—	—	—
	T-3	—	12.4	—	—	—
	T-9	—	13.0	—	—	—
Average			10.9			
Required			10.0			
7	B-3	—	—	10.0	—	—
	B-9	—	—	7.5	—	—
	T-3	—	—	11.5	—	—
	T-9	—	—	12.4	—	—
Average				10.4		
Required				11.0		
8	B-3	—	—	—	10.9	—
	B-9	—	—	—	11.5	—
	T-3	—	—	—	14.9	—
	T-9	—	—	—	10.9	—
Average					12.1	
Required					11.0	
9	B-3	—	—	—	—	10.6
	B-9	—	—	—	—	11.5
	T-3	—	—	—	—	10.6
	T-9	—	—	—	—	9.5
Average						10.6
Required						10.0

*B—Bottom (thicker end of cylinder).
T—Top (thinner end of cylinder).
3—o'clock position.
9—o'clock position.

RESULTS AND DISCUSSION

The commercial mechanical property specifications for these cylinders is 150,000-180,000 psi yield strength at 0.1 per cent offset, 22.0-20.4 per cent reduction in area and 14.0-10.0 ft-lb impact at −40 F for this yield strength range. In Table 2 are the tensile properties obtained from the test cylinders which were subjected to the rapid heat treatments. These results, compared with those listed in Table 1, which represents typical tensile properties obtained when similar cylinders are conventionally heat treated, indicated a trend existed toward improved tensile properties.

This can more readily be observed in Fig. 8, which is a bar graph of the average yield and tensile strengths listed in Tables 1 and 2. Figures 9 and 10, show that for comparable yield and tensile strengths, the ductility values of the rapidly treated specimens were superior in most cases to those obtained from conventional treatments. This was especially noticed in Fig. 10, which represents the average results of the per cent reduction in area. A substantial improvement was seen in this important mechanical property.

The specimens which were subjected to a double temper disclosed better and more uniform results than the single temper. This indicated that the shorter tempering cycles apparently were not sufficient to completely temper the specimens. A complete list of the per cent elongation and per cent reduction in area values are found in Tables 1 and 2.

Impact Values

Since it was of vital importance that cylinders of the type used in the studies contain a high degree of resistance to shock, the acquisition of any significant improvement in the impact properties would be considered a worth-while contribution. The data resulting from the five tests indicated impact values comparable to those obtained from the production treated cylinders (Fig. 11).

These impact values would be accepted under production standards. However, they were, as was the case of the conventionally heat treated cylinders, not ideal, since they were minimum average values in most instances (Tables 3 and 4). Some of the single values listed in Table 4 were encouraging, but these were offset by some low values which when averaged with the higher values, gave minimum results. Acquisition of the low values was disappointing, and it seemed to point to the fact that perhaps some incomplete transformation due to nonuniform heating was responsible. However, no studies were conducted during this investigation to substantiate this factor.

Microstructural examination of the test cylinders disclosed similar basic structures to those obtained after conventional heat treatments. The microstructure of the conventionally treated specimens revealed a small amount of tempered bainite in a matrix of tempered martensite, with precipitated carbides scattered throughout the structure especially along grain boundaries. The microstructure of the rapidly heated specimens also disclosed tempered bainite in a matrix of tempered martensite. However, a slightly greater amount of tempered bainite was present.

The amount of resolved carbide was dependent on the tempering temperature and time at temperature. The treatments requiring longer times indicated more resolved carbides present. The overall structures of these specimens were rather heterogeneous, as compared to the conventionally treated structures. However, since the mechanical properties were at least comparable to those obtained from the conventionally treated cylinders, no attempt was made to study this parameter in this phase of the investigation.

Grain Size

The grain size for the conventionally heat treated cylinders ranged from A.S.T.M. 8 to 9 throughout, while those of the rapidly heated cylinders ranged from A.S.T.M. 6 to 7 near the surface and 8 to 9 close to the bore.

In view of the test results, the application of rapid gas heating as a method of heat treating has shown some significant potentialities. Up to recent times, heating of steel for certain types of fabrication was generally done at the rate of 20 to 35 min/in. of diameter, and in many instances with highly alloyed steels even up to 60 min/in. was advocated. There was a certain amount of reluctance to heat at faster rates than mentioned above in order to avoid internal cracks caused by thermal stresses. However, no such results were experienced in this investigation.

CONCLUSION

Due consideration was given the new mechanical properties which were comparable, and in some instances superior, to those established by the conventional heat treating practices. Working within the prescribed yield strength range, the final tests indicated that most of the reduction in area properties increased in value while some of the elongation values also showed improvements. The impact properties, however, did not disclose any significant changes.

It is apparent from these studies that in order to improve the mechanical properties and to obtain a more uniform structure, a different initial prehardening treatment is necessary. These studies consisted primarily of determining the feasibility of utilizing this rapid process for heat treating cylindrical objects by comparison of mechanical properties. No quantitative attempt was made to establish any substantially different heating cycles than those used during the investigation.

The temperatures employed were basically those used in the conventional heating cycles, with some modifications to compensate for the shorter holding times. These modifications included higher austenitizing and tempering temperatures than generally used in order to obtain the required mechanical properties. Also double tempering was employed in several treatments in anticipation of obtaining more uniformity in structure and properties.

Since favorable results emanated from this work, further work will be conducted in order to study the difficulties and questionable parameters which were encountered during this investigation.

ALUMINUM FURNACE REFRACTORIES

by C. H. Schweinsberg and J. L. Dolph

ABSTRACT

Research in the development of refractories for aluminum furnaces has been particularly active in recent years. New techniques in casting and forming aluminum from an ever increasing variety of alloys has made this work important. Research leading to recent developments, as well as some test procedures, will be briefly reviewed, and compositions, properties and experience with brick, castables, ramming mixes and coating materials now available will be discussed.

INTRODUCTION

Refractories developed specifically for aluminum melting furnaces provide for substantially all the different operating conditions. There are a number of materials available to meet these varying conditions, and proper selection is necessary for best economy. Frequently, several types of refractories are tried in service to determine which is best suited to an individual operation.

A survey of literature and reports on refractories for aluminum melting furnaces reveals the wide selection of materials proposed for this application. Although some have been discarded as impractical or lacking in properties now considered essential, the work done has contributed greatly to the problems involved. Refractories which have been investigated in service include graphite, magnesite, chrome, chrome-magnesite, silicon carbide, zircon, fused alumina, magnesia-alumina spinel and fused-cast millite.

TEST PROCEDURES

Research on this particular problem has been particularly active in recent years, and new products developed are giving excellent service in numerous installations.

Long ago it was learned that molten aluminum and its alloys removed silicon from refractories, and this was identified as a thermite type, heat releasing, reaction.[1] Since silicon was objectionable in many alloys, the use of higher alumina refractories with lower silica content became widely used along with other types which resisted reaction with molten metal.

For a long time studies were made by cutting cups or troughs in brick to be tested with molten aluminum. An alloy of aluminum, such as 7075, was placed in the cup, the brick heated to a predetermined controlled temperature and held there for a definite time, usually 72 hr. After cooling, the brick was cut through the cup, and the degree of penetration or reaction was measured in comparison with a control sample.

This method is satisfactory to roughly indicate the relative merit or various compositions, but it does not simulate actual furnace conditions as well as the immersion test now used. In the immersion test, samples are partially submerged or suspended in molten aluminum in a laboratory furnace, such as the one shown in Fig. 1.

This furnace is heated by electric elements and the temperature can be closely controlled. The hearth of this particular furnace can be removed through the bottom and also serves for testing purposes. Figure 2 shows the cross-section of a test hearth built of two types of brick, differing in their ability to resist penetration of aluminum.

The modulus of rupture of a brick is a test of transverse strength and is generally considered an indication of ability to withstand mechanical abuse. The test data usually quoted are obtained at room temperatures and do not necessarily have a relation to the strength at operating temperatures. In Table 1, results are shown of tests run at 75 F (24 C) and at

TABLE 1 — MODULUS OF RUPTURE — LB/SQ IN.

	At 75 F (24 C)		At 1400 F (760 C)	
	Unused Brick	After Immersion In Molten Aluminum	Unused Brick	After Immersion In Molten Aluminum
Fireclay Brick	1550	Cracked	1640	1220
90% Alumina Brick	1370	5050	1410	1000
85% Alumina Brick, Phosphate-Bonded (Unburned)	1640	1810	2780	2390

C. H. SCHWEINSBERG and J. L. DOLPH are with Harbison-Walker Refractories Co., Pittsburgh, Pa.

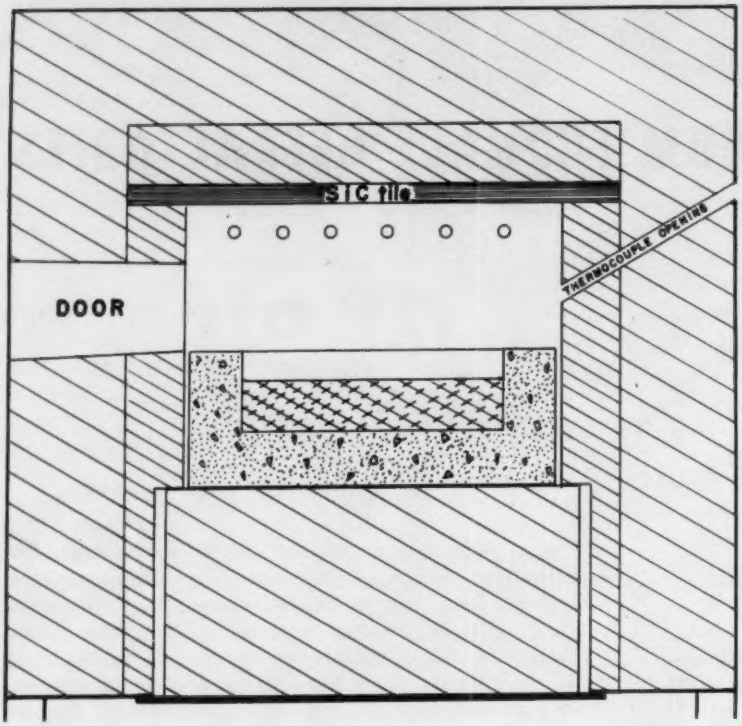


Fig. 1 — Cross-section of laboratory aluminum furnace.

1400 F (760 C) on brick before and after immersion in molten aluminum.

Of particular significance is the fact that bricks which are penetrated by aluminum in the immersion test show a resulting loss of strength in the hot modulus test.

Table 2 shows the modulus of rupture of two mortars tested under the same conditions as the brick in Table 1. The sodium silicate bonded mortar lost over 70 per cent of its transverse strength at 1400 F (760 C) due to penetration of molten aluminum, while the phosphate-bonded mortar showed no loss of strength. The effect of the aluminum reinforcement was apparent in the sodium silicate bonded mortar. The penetrated aluminum is soft at operating temperatures and is ineffective when strength is needed.

TABLE 2 — MODULUS OF RUPTURE — LB/SQ IN.

	At 75 F (24 C)		At 1400 F (760 C)	
	Unused Brick	After Immersion In Molten Aluminum	Unused Brick	After Immersion In Molten Aluminum
High-Alumina Mortar, Sodium Silicate Bond	1450	1890	1480	410
High-Alumina Mortar, Phosphate Bond	900	1020	1230	1320

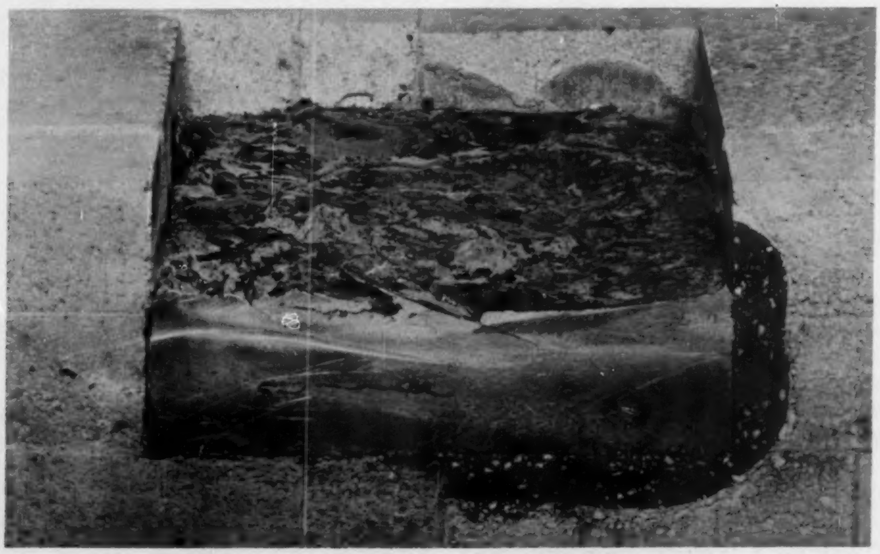


Fig. 2 — Cross-section of hearth from laboratory furnace.

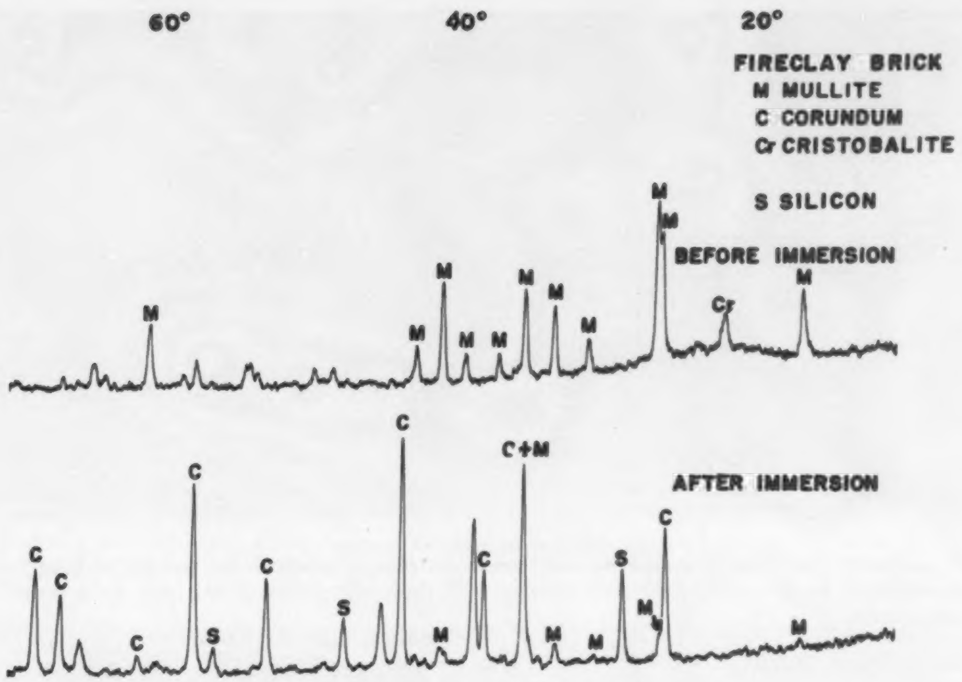


Fig. 3 — X-ray defraction of fireclay brick before and after immersion in molten aluminum.

It has been established that silicon pickup and dross buildup is generally closely proportional to the penetration and the silica content of the refractory.[2]

Figure 3 shows an x-ray diffraction pattern which graphically illustrates the crystalline phases exhibited by fireclay brick, containing approximately 40 per cent alumina (Al_2O_3), before and after immersion in molten aluminum for three days at 1500 F (816 C). The original brick was composed principally of mullite ($3\,Al_2O_3 \cdot 2\,SiO_2$), some cristobalite and a moderate amount of amorphous material which is probably glass.

After immersion, there was no detectable cristobalite, the mullite had been reduced by 85 per cent and the glass is significantly less. However, there are now present sizable amounts of corundum, elemental silicon and aluminum metal. Obviously, the silica has been reduced to silicon and picked up by the aluminum.

This reaction would decrease with increased alumina content, and should be negligible with refractories in the 85 to 99 per cent alumina class.

Laboratory results are important for determining the types or composition of refractories that could be economically adapted to operating conditions. Test panels in production furnaces also are important, and frequently will give positive indication of the service that may be expected. However, the only true test is a complete installation in a furnace operating under conditions for which the refractory is designed.

TYPES OF REFRACTORIES

In the upper side walls and roofs, high-duty or super-duty fireclay brick, plastics or castables are usually adequate, with the trend toward the superduty materials. The critical parts in an aluminum melting furnace are the bottom and side walls to a point approximately 12 to 18 in. above the sill level. Dense, high-duty fireclay brick of the class used in iron blast furnaces continue to be used widely, particularly where alloying and fluxing conditions are not severe.

High-alumina bricks of 60 per cent Al_2O_3 content are also used extensively, and one operator has described this type as the workhorse of his furnace. Frequently, 60 per cent Al_2O_3 brick have proved to be a satisfactory compromise between high-duty fireclay brick and the types containing 85 per cent or more Al_2O_3 which costs more. Bricks having an alumina content of 90 per cent have been outstanding when operating conditions are severe and when critical alloys are being melted.

High-duty fireclay brick and high-alumina brick of both 60 to 90 per cent Al_2O_3 classes are all reacted and penetrated to a degree which in some cases can be damaging. The cup test in Figure 4 shows a high-duty fireclay brick after 30 hr at 1700 F (927 C) using 7075 alloy. It will be observed that there is a definite separation between the penetrated and unpenetrated zones. This is typical of brick which are readily penetrated, but is much less apparent with 90 per cent alumina brick. It has also been observed that 90 per cent alumina bricks which have been reacted show little, if any, change in volume.

Actually, this separation, or crack, may be a fallacy of the cup test and does not necessarily occur in service, since these types of brick have frequently given years of service with no evidence of such damage. Ninety-nine per cent Al_2O_8 bricks of excellent

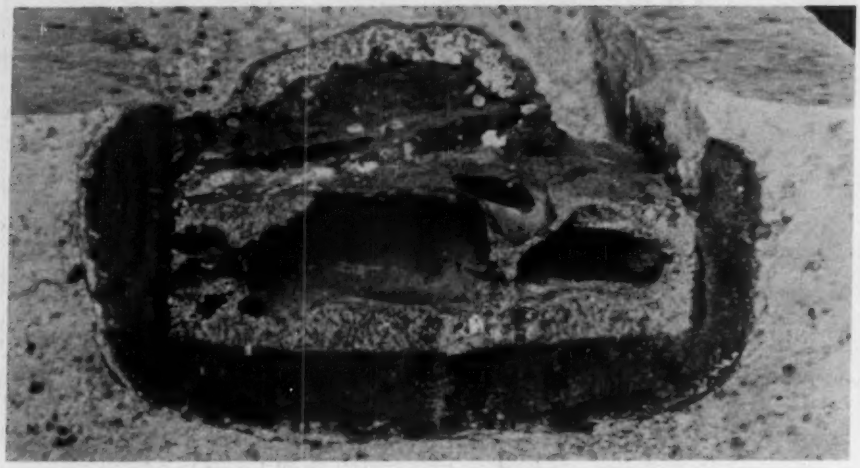


Fig. 4 — Cup test showing aluminum penetration in fireclay brick.

quality are produced, but due to cost their use has been largely confined to operations for which extreme purity is paramount.

85 Per Cent Alumina Brick

Within the past several years 85 per cent alumina bricks made with special bonding agents or additives to increase resistance to metal penetration have been developed. Most prominent have been the phosphate-bonded brick which are manufactured both unburned and high fired.

The unburned type is cured at approximately 500 F (260 C) to 600 F (316 C) to stabilize the aluminum-phosphate bond. These bricks have excellent resistance to penetration, but generally are not as strong as the high-fired types. The modulus of rupture of the unburned brick ranges from 1100 to 2200 psi, as compared to over 3000 psi or higher for the fired brick. Unburned phosphate-bonded brick with alumina content as low as 50 per cent have been developed, and are best adapted principally for lining furnaces operated under relatively moderate conditions.

The high-fired 85 per cent alumina phosphate-bonded brick have unusual strength and also excellent resistance to reaction. They are used successfully in furnaces where contamination from the refractory would be objectionable, and they also contribute to easier cleaning of the furnace walls.

More recently, bricks of 85 per cent alumina content or higher bonded by special chemical additives have been developed. Preliminary trials indicate that their resistance to penetration or reaction by molten aluminum will be superior to that of other high-alumina refractories. This is illustrated by Fig. 5, in which the new type refractory is compared with a 90 per cent alumina brick after immersion in molten aluminum for three days. Figure 6 illustrates the same two brands of brick after three weeks in molten aluminum.

Hard-burned chrome and chrome-magnesite bricks have excellent resistance to wetting by molten aluminum, but their spalling and impact resistance is lower than that of most high-alumina brick. They are particularly adapted for use in holding furnaces where charging practices are not so severe.

Silicon Carbide Brick

Silcon carbide bricks, have good strength, and since dross does not readily adhere to them cleaning is simplified. Formation of aluminum carbide will result in disintegration of the brick during shutdown periods, but special compositions have been developed to retard this reaction. Silicon nitride bonded silicon carbide bricks are used principally for tap-out shapes, pyrometer tubes and pump parts. High cost is a limiting factor to the wide use of these refractories.

Zircon bricks are not penetrated by molten aluminum at normal operating temperatures, but they do not withstand the mechanical abuse or impact of hard charging practices. Zircon, the silicate of zirconium, is an acid refractory and may be damaged by basic fluxes at high temperatures. Zircon bricks also are of relatively high cost, and they are used principally in furnaces where metal purity is paramount.

The bonding mortar used with any type of brick is highly important, since weak or readily penetrated joints are vulnerable to attack. It is generally recognized that mortars bonded with sodium silicate react with aluminum, as illustrated in Fig. 7. This reaction is frequently accompanied by expansion of the joint, resulting in distortion of the wall. Phosphate-bonded zircon and high-alumina mortars are now available which are resistant to penetration. Figure 8 illustrates this clearly. The bricks are of the 90 per cent alumina class, and the mortar is a phosphate-bonded 85 per cent alumina material.

Plastics, castables and ramming mixes have been used with varying results. Most of these materials are not greatly reacted upon but lack adequate strength at operating temperatures, which largely restricts their use to furnaces employing moderate charging procedures. However, monoliths have been entirely adequate in many applications.

Chrome base castables especially are nonwetting, and when installed by ramming, rather than casting, have given satisfactory service. Chrome castables also show promise used as a maintenance material when

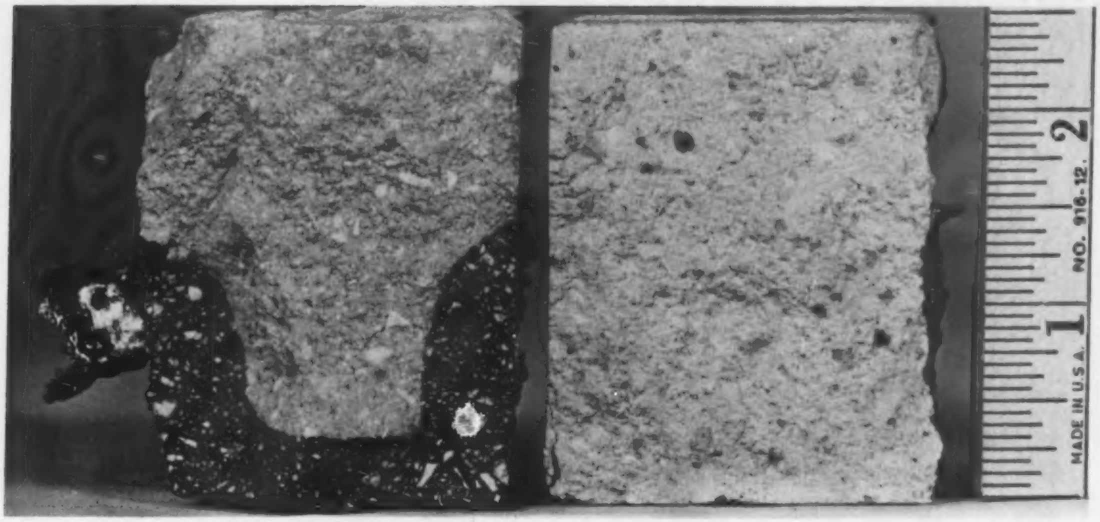


Fig. 5 — Comparison between 90 per cent alumina brick. *(left)* and special bonded 85 per cent alumina brick *(right)* after three days in molten aluminum.

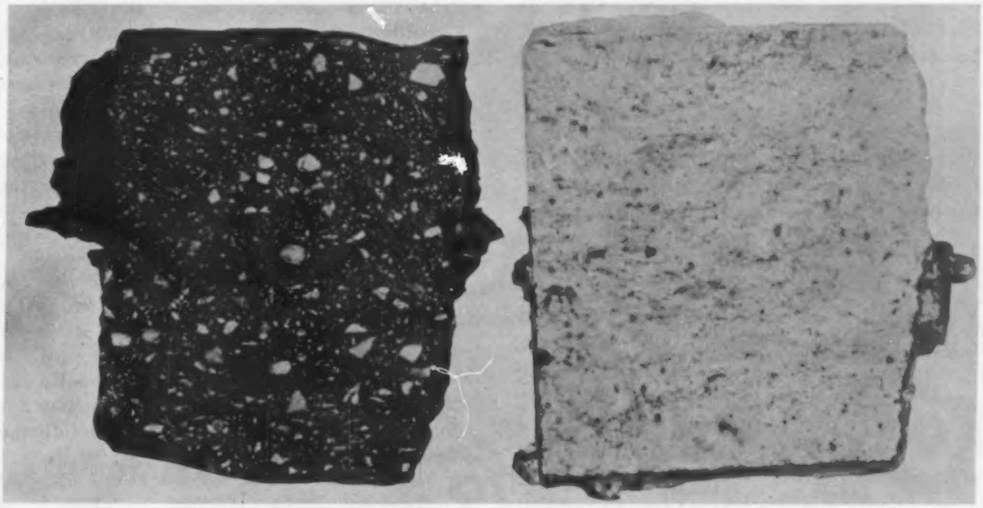


Fig. 6 — Same as Fig. 5, after 3 weeks.

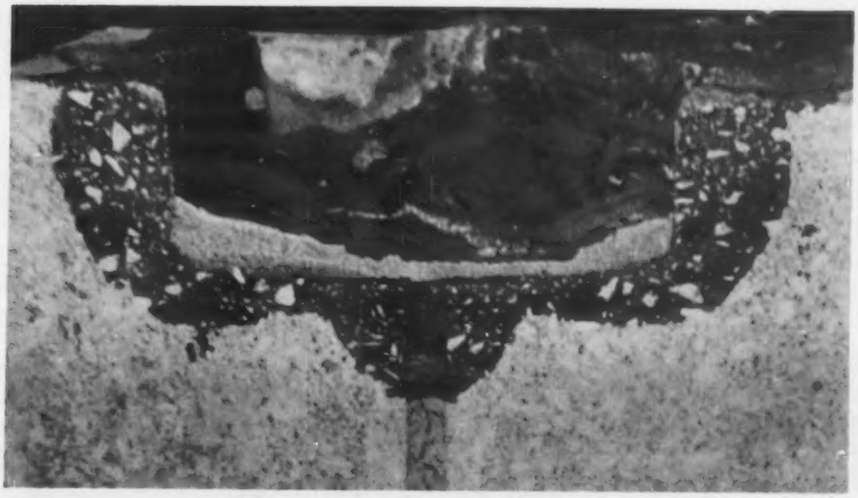


Fig. 7 — Attack of molten aluminum on mortar containing silicate of soda.

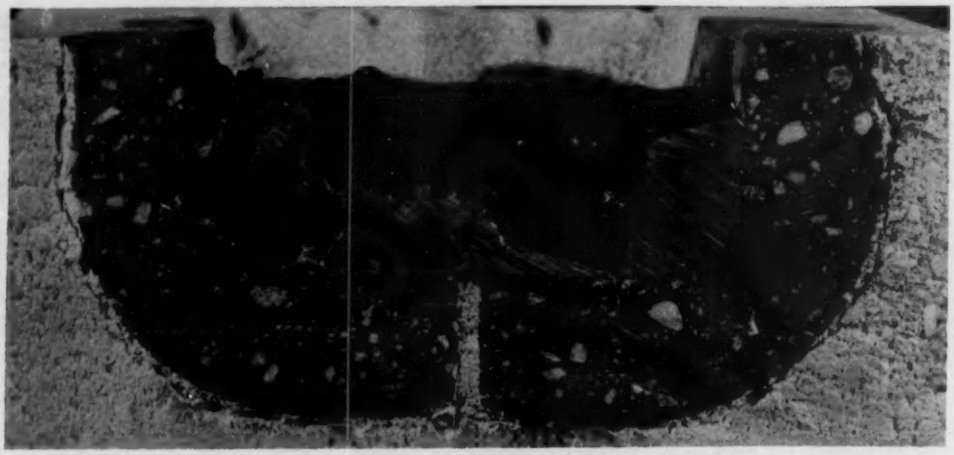


Fig. 8 — Resistance to attack by molten aluminum of phosphate-bonded high-alumina mortar.

applied by the air-placement method. Phosphate-bonded high-alumina ramming mixes are also being used with satisfactory results. This particular type of ramming mix, when properly installed, will develop good strength that is maintained throughout the entire range of operating temperatures.

Furnace Lining Impregnation

Impregnation of aluminum melting furnace linings with a mixture of 80 per cent sodium chloride ($NaCl$) and 20 per cent cryolite (Na_3AlF_6) apparently originated in Europe, possibly due to the limited availability of refractories which would retard silicon pickup. Impregnation is accomplished by melting the mixture of salt in the furnace and slowly raising the level of the molten salt by additions of hot or cold metal. The melting point of this mixture is 1463 F (795 C).[3] The molten salt penetrates the brick, filling the pores, and to a degree is effective in retarding penetration by molten metal. Although there are a number of such installations on this continent, cost information is not available.

Various materials for coating refractories to prevent penetration have been proposed and tried over the years. An early reference suggested "aluminum bronze varnish," ordinary graphite blacking as used in the foundry and finely ground dead-burned magnesite.[4] Another reference proposed various mixtures such as calcined kyanite and calcium carbonate in 2 to 1 ratio, ball milled with sodium silicate.[5] More recently, a coating compound composed principally of boric acid has been developed.[6] Coating the brick with phosphate-bonded high-alumina mortar is also recommended. Coating materials do have some immediate effect in retarding penetration, but this is generally of only a temporary nature.

SUMMARY

The refractory most suitable for lining the hearths of aluminum melting furnaces should possess several superior properties. Resistance to penetration and reaction by molten aluminum and its numerous alloys is most important. This property retards contamination, reduces metal loss in the refractory, makes for easier cleaning and obviously extends service life of the furnace. Almost equally important is sufficient strength at operating temperatures to withstand mechanical abuse.

Other desirable characteristics include resistance to thermal shock, adequate refractoriness, dimensional accuracy and, of course, cost commensurate with service performance. Several refractories developed specifically for this application closely approximate the optimum in this combination of desirable properties. However, because of the many variables involved in melting aluminum, selection of the refractories for each individual unit must be made on the basis of operating conditions and economic considerations.

Average service life for a particular refractory is difficult to evaluate, since so much depends on melting rates, alloys melted, size and design of furnaces and other pertinent factors. Probably the best estimate would be on the basis of pounds of aluminum melted, and some authorities feel that 35 million to 50 million lb normally is satisfactory furnace life.

CONCLUSION

Research on refractories for aluminum melting is continuing, and new products still in the development stage or in trial installations should contribute to increased economies. As new products are developed, the cooperation of operators in arranging trial installations is essential, since laboratory equipment can simulate actual furnace conditions only to a limited extent.

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CAST NICKEL CONTAINING ALUMINUM BRONZE PROPERTIES AND MICROSTRUCTURE

by E. Belkin

ABSTRACT

A study has been made of the properties and microstructure of aluminum bronze alloys containing 9.5 to 11.5 per cent aluminum, 3 to 6 per cent iron and 3 to 6 per cent nickel.

Mechanical properties and microstructures were examined for as-cast alloys to determine the separate effects of aluminum, iron and nickel. It was found that aluminum has a greater effect on properties and structure than do the other two elements. Nickel causes an increase in ductility at the highest aluminum content by reducing the amount of beta phase and increasing the amounts of alpha phase. Iron adds to the hardness, but variations in iron have no other significant effect on the properties measured. No attempt was made to measure the effect of iron on grain size.

Microstructure, hardness and tensile properties were determined after various heat treatments of one alloy. The effect of quenching and air cooling from temperatures ranging from 1000 C (1832 F) to 500 C (932 F) was studied by hardness measurements and by microscopic examination. Tensile properties were studied after various quenching and tempering combinations, which included quenching temperatures of 900 C (1652 F), 850 C (1562 F) and 800 C (1472 F); tempering temperatures of 700 C (1292 F) and 600 C (1112 F); and air cooling and quenching from the tempering temperatures.

INTRODUCTION

Aluminum bronze alloys are one of the two groups of copper-base casting alloys which are commonly used for high-strength structural applications. Of these, the alloy used for the most severe structural applications is the nickel containing variety identified as A.S.T.M. B148-52, Alloy 9D. With increasingly severe service applications there is the corresponding increase in the demand for higher strength materials, and, thus, the aluminum bronze alloys can be expected to find wider application.

Because published data are scarce concerning the effect on mechanical properties of variations in composition and of various heat treatments for the cast nickel containing aluminum bronze alloys, an investigation is being conducted related to the highest strength alloys. Without such information, the foundryman and designer are at a loss to choose a composition which best fits the application, or to explain some of the service or processing difficulties relating to composition or heat treatment. There is, however, considerable information regarding wrought aluminum bronze alloys. Especially noteworthy is the work by Cook, et al.[1]

Results are described on the hardness, tensile properties and microstructure of as-cast and heat-treated material within the composition ranges of 9 to 12 per cent aluminum and 3 to 6 per cent each of iron and nickel. Most of the data are based on small heats made under laboratory conditions, and are thus preliminary to additional studies which should be made with material produced in a commercial foundry.

PROCEDURES AND RESULTS

All heats were made using O.F.H.C. copper in combination with master alloys of copper-aluminum, copper-nickel, copper-iron and copper-manganese. All the heats except one were melted in a high frequency induction furnace of 60 lb capacity and tapped into two core sand Y-block molds. In Fig. 1 are shown a typical mold and casting used for these studies. The melting procedure used for the laboratory heats is:

1. 50-50 copper-aluminum, 90-10 copper-iron, 50-50 copper-nickel and O.F.H.C. copper charged into furnace.
2. Molten at about 1200 C (2192 F).
3. 70-30 copper-manganese added, stirred.
4. Held for 5 min.
5. Power turned off, metal frozen to reduce gas content.
6. Remelted.
7. Added 0.1 per cent cryolite, stirred, skimmed.
8. Tapped into tundish.
9. Metal held till temperature dropped to approximately 1175 C (2147 F).

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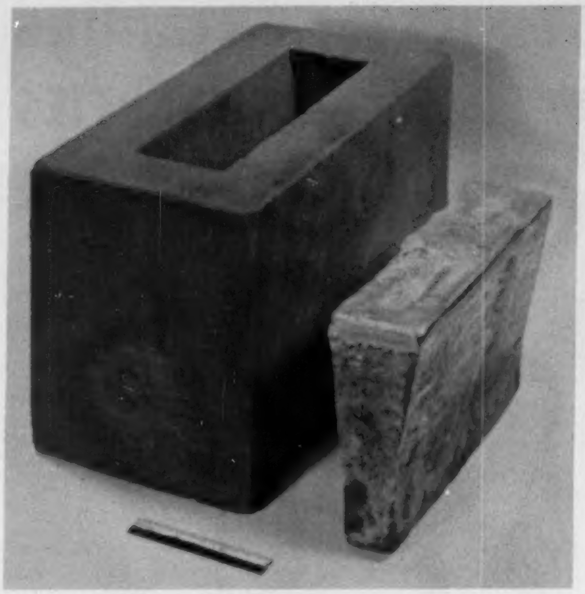


Fig. 1 — Mold and ingot made in the laboratory heats.

10. Removed stopper and poured into two Y-bar molds in succession. Each ingot was allowed to cool to about room temperature before removal from the mold.

The first phase consisted of making a number of heats to explore the effect of variations in aluminum, iron and nickel on as-cast tensile properties.

Two 7/8-in. thick slices were cut longitudinally from each ingot and later machined into 0.505 in. diameter tensile bars. The ends of each slice were sectioned for microscopic examination and chemical analysis.

Mechanical Properties of As-Cast Alloys

Table 1 lists the composition, as-cast room temperature tensile properties and hardness for each of the alloys studied in this phase. Each value represents the average of two tests. The data for the sand cast material are arranged so that each group represents one aluminum level. Within each group the alloys are arranged in order of increasing iron content.

It can be seen that the major effects of increasing aluminum content from 9.5 to 10 per cent are to reduce the percentage elongation and increase the hardness. Lesser effects are noted in the increase in yield strength and ultimate strength. With an increase to 10.5 per cent aluminum, the decrease in elongation and increase in hardness is less pronounced for the group, but the increase in yield strength and ultimate strength is similar to that noted for an increase from 9.5-10 per cent aluminum. The pattern of increase in yield strength and hardness continues with increase in aluminum to 11.5 per cent, but elongation

TABLE 1 — COMPOSITION AND MECHANICAL PROPERTIES OF SAND CAST ALLOYS IN AS-CAST CONDITION

Heat No.	Intended Analysis, %				Actual analysis, %				Yield Str., 0.2% Offset, psi	Ultimate Str., psi	Elong., % in 2 in.	Bhn, 3000 Kg
	Al	Fe	Ni	Mn	Al	Fe	Ni	Mn				
1	9.5	3	3	0.5	9.37	3.16	3.10	0.60	34,500	88,000	25	143
2	9.5	3	5	0.5	9.4	2.74	5.23	0.55	37,000	86,000	20	149
3	9.5	4	4	0.5	9.4	4.14	3.80	0.49	32,500	92,000	23	152
4	9.5	4.5	3.5	0.5	9.4	4.61	3.68	0.54	34,500	94,500	25	156
5	9.5	5	5	0.5	9.42	4.80	5.11	0.60	40,000	93,500	19	163
6	10	3	6	0.5	10.2	2.86	6.26	0.54	46,000	91,000	10	170
7	10	4	4	0.5	9.8	4.25	3.88	0.31	37,000	93,000	15	167
8	10	5	3	0.5	10.2	5.15	3.27	0.54	40,000	94,500	11	179
9	10	5	5	0.5	9.9	4.76	5.08	0.50	38,000	95,000	15	170
10	10	6	6	0.5	9.8	6.05	6.03	0.48	40,000	91,000	10	181
11	10.5	3	3	0.5	10.3	2.84	3.07	0.55	36,000	94,000	11	170
12	10.5	4.5	6	0.5	10.4	4.30	5.88	0.54	42,000	100,000	14	187
13	10.5	5	5	0.5	10.7	4.97	4.97	0.45	45,500	101,000	9	197
14	10.5	5.5	5.5	0.5	10.4	5.69	5.39	0.52	41,500	102,000	15	187
15	10.5	6	6	0.5	10.5	5.80	6.13	0.51	45,000	98,000	8	193
16	11	3	3	0.5	11.0	3.06	3.15	0.60	50,000	100,000	6	207
17	11	3	5	0.5	10.8	2.89	5.26	0.55	51,000	106,000	10	197
18	11	3	6	0.5	11.1	2.86	6.10	0.55	49,000	100,500	9	201
19	11	4.5	3	0.5	10.9	4.47	3.17	0.55	45,500	98,500	7	207
20	11	5	5	0.5	11.0	4.80	5.30	0.60	55,000	107,500	10	197
21	11	5.5	5	0.5	11.2	5.63	5.05	0.54	48,000	107,000	10	207
22	11.5	3	3	0.5	11.6	3.11	3.09	0.63	53,000	103,000	4	235
23	11.5	3	5	0.5	11.6	2.85	5.35	0.54	52,000	109,000	8	217
24	11.5	5	5	0.5	11.4	4.54	5.31	0.61	59,000	108,000	7	217
25	11.5	5.5	5.5	0.5	11.8	5.65	5.58	0.54	53,500	111,500	8	223

and ultimate strength show almost no change upon increasing the aluminum content from 11 to 11.5 per cent.

To study the effect of aluminum more closely, it is desirable to compare compositions in which only the aluminum content varies. Tensile and hardness data in the form of curves are shown in Fig. 2 for alloys which have approximately 3 per cent iron and 3 per cent nickel but different amounts of aluminum, and for a second group with 5 per cent each iron and nickel. Depicted in this fashion, it can be seen that changes in aluminum content between 9.5 and 11.5 per cent strongly affect tensile and hardness properties. The property changes are similar in degree for both the 3 per cent nickel-iron alloys and the 5 per cent nickel-iron alloys.

There is no significant influence on properties as a result of increasing iron from 3 to 6 per cent at any of the aluminum values, except the slight increase in hardness at 9.5 per cent aluminum. Similarly, variations in nickel between 3 and 6 per cent have little effect on properties, except that at 11 and 11.5 per cent aluminum the elongation increases when nickel is increased. At the highest aluminum level, an increase in nickel from 3 to 5.5 per cent causes the hardness to drop slightly.

The data in Table 2 and Fig. 2 confirm that aluminum has a greater effect on properties than do nickel or iron.

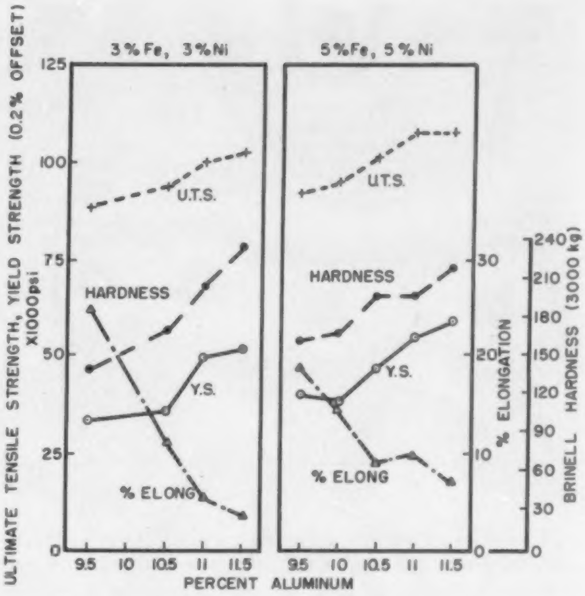


Fig. 2 — Relationship between aluminum content and mechanical properties of cast alloys.

Microstructures of Sand Cast As-Cast Alloys

Increases in aluminum content result in an increase in the amount of hard, brittle eutectoid phase and beta phase at the expense of the soft, ductile alpha phase. Photomicrographs in Fig. 3 show microstructures of four heats, 1, 11, 16 and 22 in which the iron and nickel contents are approximately 3 per cent. Tensile properties and compositions of the respective heats are shown adjacent to each photomicrograph.

TABLE 2 — MECHANICAL PROPERTIES OF SAND CAST ALLOYS IN HEAT TREATED CONDITION

Heat No.	Intended Analysis, %				Yield Str., 0.2% Offset, psi	Ultimate Str., psi	Elong., % in 2 in.	Bhn, 3000 Kg
	Al	Fe	Ni	Mn				
1	9.5	3	3	0.5	40,000	93,000	25	163
2	9.5	3	5	0.5	49,000	101,000	14	197
3	9.5	4	4	0.5	44,500	97,000	17	179
4	9.5	4.5	3.5	0.5	43,000	99,000	23	179
5	9.5	5	5	0.5	44,000	96,500	13	185
6	10	3	6	0.5	61,000	111,000	9	229
8	10	5	3	0.5	61,500	103,000	6	201
9	10	5	5	0.5	52,000	102,000	10	201
12	10.5	4.5	6	0.5	55,000	108,500	11	217
14	10.5	5.5	5.5	0.5	56,500	107,000	10	209
16	11	3	3	0.5	57,000	111,000	8	220
17	11	3	5	0.5	79,500	118,500	8	241
18	11	3	6	0.5	76,500	116,500	6	241
19	11	4.5	3	0.5	63,000	116,000	10	229
20	11	5	5	0.5	82,500	119,600	7	246
21	11	5.5	5	0.5	73,500	116,000	8	229
22	11.5	3	3	0.5	51,500	104,500	5	229
23	11.5	3	5	0.5	86,500	121,000	6	251
24	11.5	5	5	0.5	83,500	121,000	6	251
25	11.5	5.5	5.5	0.5	88,000	124,500	6	255

Treatment: 850 C (1562 F) — one hr, W.Q., 700 C (1292 F) — 2 hr, A.C.

TABLE 3 — COMPOSITION OF SAND CAST KEEL BARS USED FOR HEAT TREATMENT STUDIES

Heat No.	Chemical Analysis, % Cu	Al	Fe	Ni	Mn
61	80.96	10.6	3.92	4.08	0.56

Qualitative Spectrographic Analysis	Estimated Concentration, %
Pb	0.03
Ag	0.015
Sn	0.015
Mg	0.003
Si	0.003
Co	0.003

The photomicrographs in Fig. 4 of alloys 5, 9, 13, 20 and 24 show the effect of increasing the aluminum content from 9.5 to 11.5 per cent when the iron and nickel contents are approximately 5 per cent. In these structures, the result of higher aluminum content can be seen as an increase in the amount of eutectoid, a decrease in the amount of alpha and an increase in the amount of beta. The increase in eutectoid content accounts for the decrease in ductility and the increase in hardness.

As can be seen by comparing the photomicrographs in Figs. 3 and 4, the effect of increasing the nickel content from 3 to 5 per cent is to cause the eutectoid to be less massive, the alpha phase to be present in smaller, less rounded form and to reduce the amount of beta phase. In addition, these two groups of photomicrographs reveal that increasing the iron content from 3 to 5 per cent causes greater amounts of the spheroidal aluminum-rich iron particles, called kappa phase, to be present.[2-3] For equal variations, aluminum is obviously more effective than nickel or iron in causing changes in properties and microstructures.

TABLE 4 — HARDNESS OF AN ALUMINUM BRONZE ALLOY* AS-QUENCHED AND AS-AIR COOLED FROM ELEVATED TEMPERATURES

Heat Treatment Temp., C (F)	Bhn, 3000 Kg, Cooling Rate Water Quench	Air Cooled
1000 (1832)	309**	241
950 (1742)	340**	232
900 (1652)	313**	232
850 (1562)	323**	226
800 (1472)	255	217
750 (1382)	214	197
600 (1112)	—	181
500 (932)	—	189

NOTES:

*Heat 61 — see Table 3 for composition.

**Converted from D.P.H. (10 Kg) numbers. As Received hardness — Bhn 185

Mechanical Properties of Heat Treated Alloys

Sections of the alloys cast in sand molds were heated to 850 C (1562 F) for one hr quenched into water, heated to 700 C (1292 F) for 2 hr and air cooled to room temperature. The temperatures were maintained within ± 5 degrees C. These bars were then machined into standard 0.505 in. diameter tensile bars and tested at room temperature, with the results shown in Table 2. Although the tensile results for the heat-treated alloys are discussed in this part of the report, the heat treatment was selected on the basis of studies described in a later portion. Not all of the tensile results are included because examination of the fractured bars revealed that some bars were unsound.

To evaluate the result of heat treatment of these alloys, it is necessary to compare the tensile results in Table 2 with the as-cast properties listed in Table 1 for the same alloys. At 9.5 per cent aluminum, the heat-treated alloys show a relatively small increase in yield strength, ultimate strength and hardness accompanied by a slight decrease in elongation. At 10 per cent aluminum, the increase in strength and hardness is somewhat greater and the loss in ductility is more severe. For the 10.5 to 11 per cent aluminum alloys, heat treatment causes the largest increase in yield strength compared to the other aluminum ranges. Ultimate strength and hardness also increase on heat treating, and the elongation decreases in about the same degree as in the lower aluminum range alloys.

A comparison of alloys in which the percentage of aluminum and iron is constant, but the nickel differs, shows that at 9.5, 11 and 11.5 per cent aluminum the effect of higher nickel is to cause a considerable increase in yield strength in the heat-treated alloys. This increase is accompanied by loss in ductility at 9.5 per cent aluminum, but no change at other aluminum levels. Note the properties listed in Table 2 for alloys 1 and 2 with 3 and 5 per cent nickel, respectively; alloys 16, 17 and 18 with 3, 5 and 6 per cent nickel, respectively; and alloys 22 and 23 with 3 and 5 per cent nickel, respectively. The lack of compositions with precisely the same aluminum and iron content prevents the analysis of the effect of nickel for the 10 and 10.5 per cent aluminum ranges.

Various Cooling Rates From Quenching Temperatures Effect

To study the effect of various heat treatments, 12 keel bars made from one 300 lb heat were obtained from a commercial foundry. The composition of this heat, assigned number 61, is shown in Table 3. Several bars were cut into slices approximately ½-in. by one in. by one in. for heat treatment. After one hr at one of the following temperatures: 1000 C (1832 F), 950 C (1742 F), 900 C (1652 F), 850 C (1562 F), 800 C (1472 F), 750 C (1382 F), 600 C (1112 F) and 500 C (932 F), one piece from each temperature was cooled in air to room temperature. In addition, one piece from each temperature, except the last two, was quenched into water. Hardness measurements made

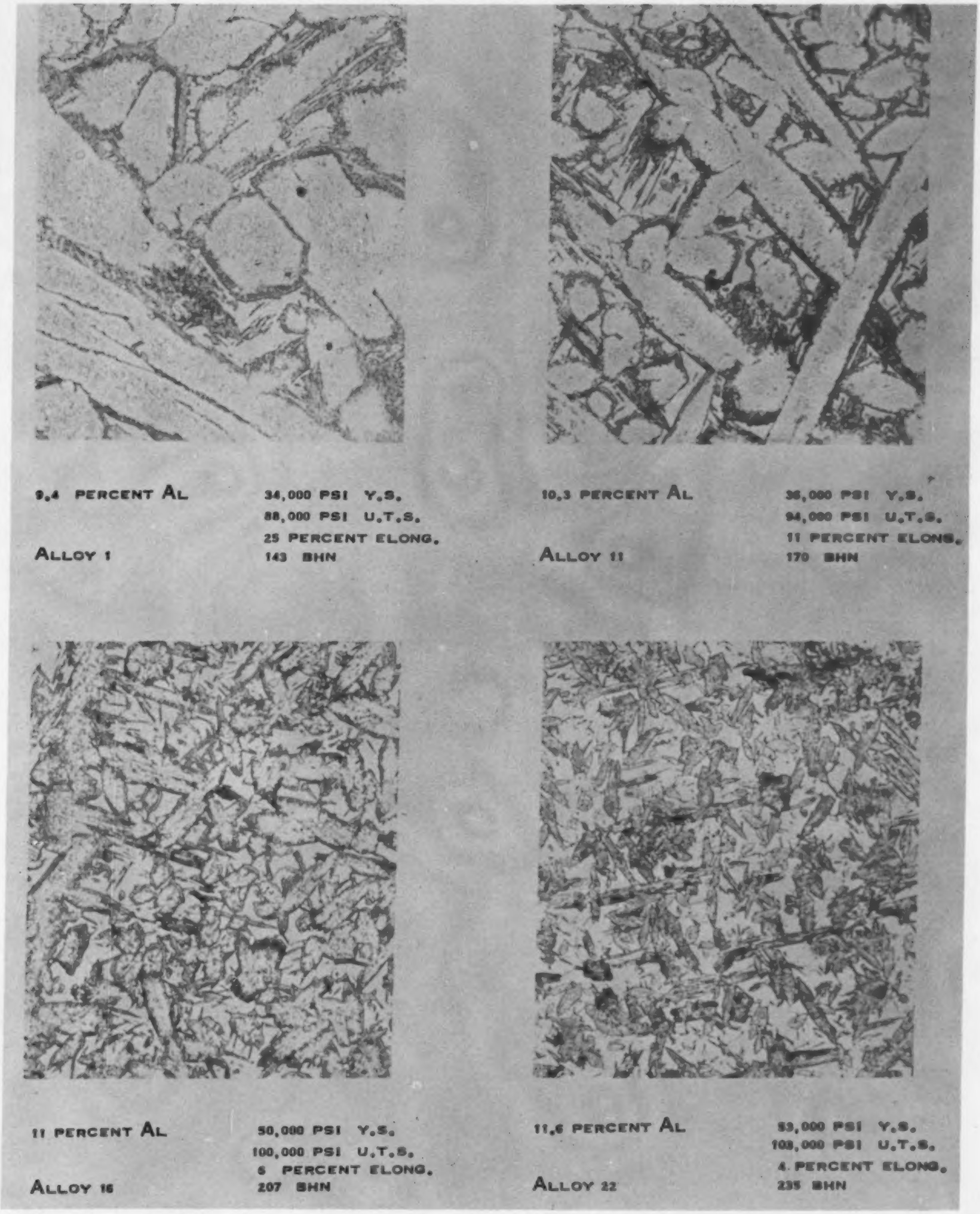
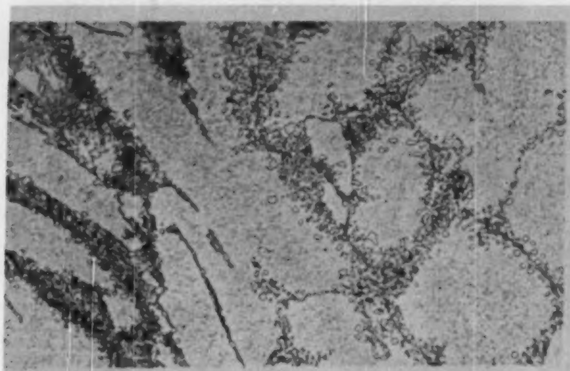


Fig. 3 — Microstructures and associated properties related to aluminum content for as-cast aluminum bronzes. Nominal composition for each alloy — 3 per cent Fe, 3 per cent Ni, 0.5 per cent Mn, Al as shown, balance Cu. One per cent chromic acid etch. 250 ×.



9.4 PERCENT AL

ALLOY 5

40,000 PSI Y.S.
93,500 PSI U.T.S.
18 PERCENT ELONG.
163 BHN

9.9 PERCENT AL

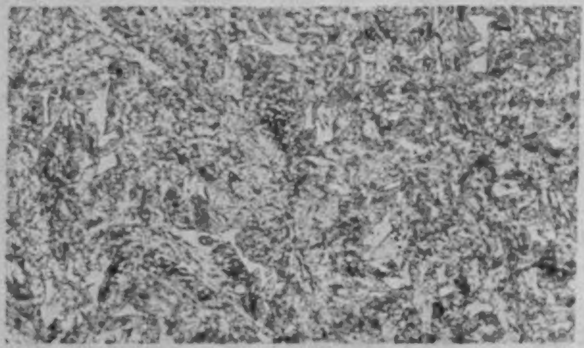
ALLOY 9

38,000 PSI Y.S.
95,000 PSI U.T.S.
15 PERCENT ELONG.
170 BHN

10.7 PERCENT AL

ALLOY 13

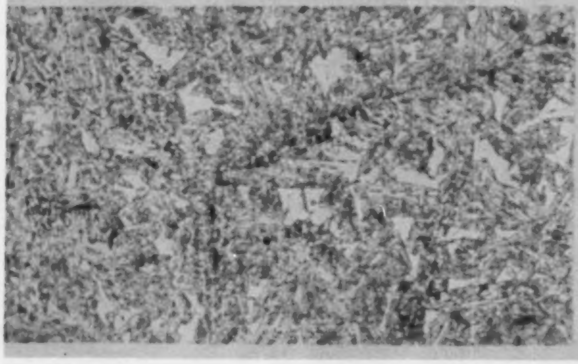
45,500 PSI Y.S.
101,000 PSI U.T.S.
9 PERCENT ELONG.
197 BHN



11 PERCENT AL

ALLOY 20

55,000 PSI Y.S.
107,500 PSI U.T.S.
10 PERCENT ELONG.
197 BHN



11.4 PERCENT AL

ALLOY 24

59,000 PSI Y.S.
108,000 PSI U.T.S.
7 PERCENT ELONG.
217 BHN

Fig. 4 — Microstructures and properties related to aluminum content for as-cast aluminum bronzes. Nominal composition for each alloy — 5 per cent Fe, 5 per cent Ni, 0.5 per cent Mn, Al as shown, balance Cu. One per cent chromic acid etch. 250 ×.

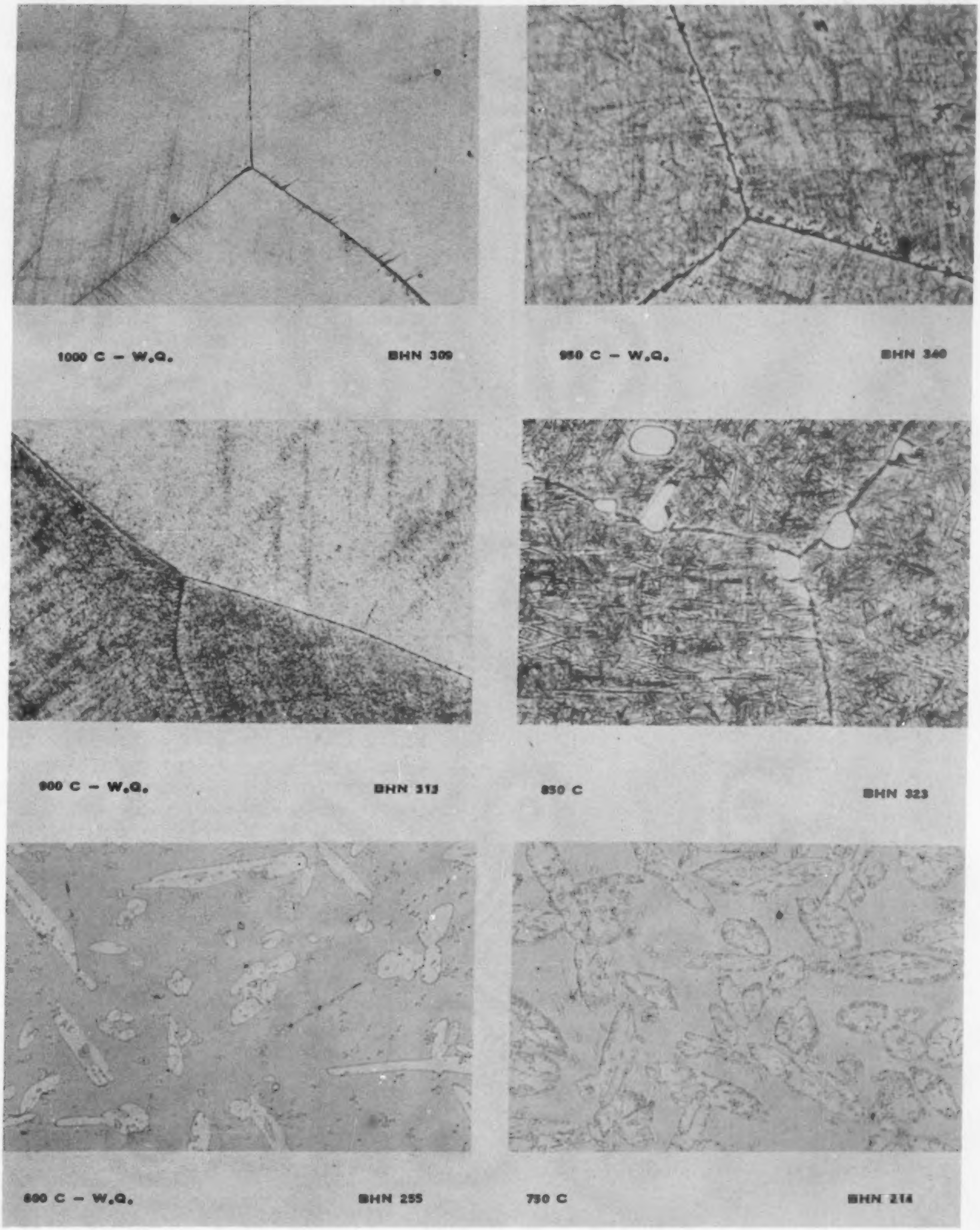


Fig. 5 — Microstructures of cast aluminum bronze from heat 61 on quenching into water from indicated temperatures. One per cent chromic acid etch. 250 ×.

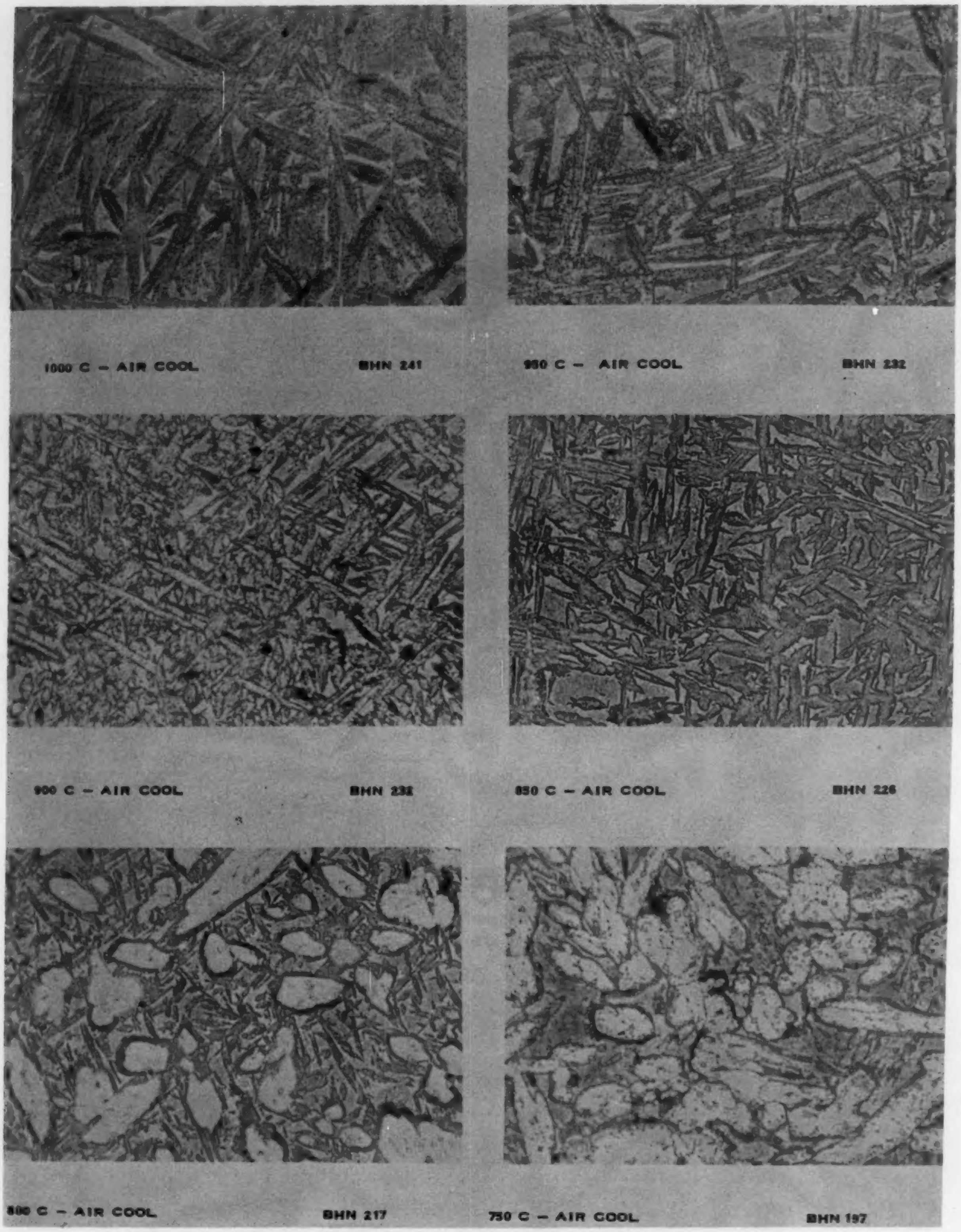


Fig. 6 — Microstructures of cast aluminum bronze from heat 61 on cooling in air from indicated temperatures. One per cent chromic acid etch. 250 ×.

on each piece after quenching or cooling in air are listed in Table 4.

Samples quenched from 850 C (1562 F), 900 C (1652 F) or 950 C (1742 F) have approximately the same hardness, whereas the as-quenched hardness is lower when the quenching temperature is reduced to 800 C (1472 F) and the hardness is further reduced on quenching from 750 C (1382 F). Air-cooled samples attained maximum hardness upon cooling from 1000 C (1832 F). With lower heating temperatures, the hardness after cooling to room temperature was less, except that the piece cooled from 500 C (932 F) was harder than the 600 C (1112 F) sample.

In every case, the quenched samples were harder than those air cooled from the same temperature. This difference is an expected result of the formation of larger amounts of the martensitic phase on rapid quenching.[4] An explanation of the increase in hardness at 500 C (932 F) is that some of the beta phase in the as-cast material decomposed to the harder eutectoid phase.

Microstructures of Material As-Quenched and As-Air-Cooled From Elevated Temperatures

Photomicrographs in Fig. 5 trace the transformation which takes place upon quenching from temperatures ranging from 1000 C (1832 F) to 750 C (1382 F). On quenching from the highest temperature, the structure is almost completely martensitic. The 850 C (1562 F) sample contains alpha phase in the form of needles, as spheroidal particles at the grain boundaries and as spheroids within the grains. The structure of the 800 C (1472 F) material consists of a beta matrix and elongated particles of alpha.

In this structure, the aluminum-rich iron particles (kappa phase) are clearly visible in the form of small rosettes or spheroids. At still lower quenching temperature of 750 C (1382 F) some eutectoid has formed, and is seen as the dark shading around the edge of the alpha particles. It is noticeable also that the alpha particles are less elongated. The matrix phase in this structure is beta.

The microstructures, shown in Figs. 6 and 7 of the samples air cooled from 1000 C (1832 F), 950 C (1742 F), 900 C (1652 F) and 850 C (1562 F), are quite similar in that the matrix is a mixture of beta and elongated particles of alpha. There is fine eutectoid within the alpha particles for each of the above microstructures but there is somewhat more alpha at the lowest temperature 850 C (1562 F). After cooling in air from 800 C (1472 F) the alpha phase appears in a more rounded form, the eutectoid is slightly coarser and some eutectoid is seen scattered in the beta matrix.

In this structure, the kappa is visible as rosettes and spheroids. The samples cooled from 750 C (1382 F) and 600 C (1112 F) are quite similar, except that the lower temperature structure has more beta, the remainder of structure being composed of alpha and eutectoid. Kappa phase is visible in both structures. As a matter of reference, the microstructure of the material in the as-received condition is shown.

Fig. 7 — Microstructures of cast aluminum bronze of heat 61 on cooling in air from indicated temperatures. Alloy in as-cast condition is shown for comparison. One per cent chronic acid etch. 250 ×.

TABLE 5 — HARDNESS OF AN ALUMINUM BRONZE ALLOY* AFTER QUENCHING AND TEMPERING

Heat Treatment		Bhn, 3000 Kg, After Tempering	
Quenching Temp., C (F)	Tempering Temp., C (F)	Water Quenched From Tempering Temp.	Air Cooled From Tempering Temp.
900 (1652)	400 (752)	380**	
(1652)	(752)		380
(1652)	500 (932)	302	
(1652)	(932)		302
(1652)	600 (1112)	255	
(1652)	(1112)		255
(1652)	700 (1292)	229	
(1652)	(1292)		217
800 (1472)	400 (752)	269	
(1472)	(752)		265
(1472)	500 (932)	229	
(1472)	(932)		229
(1472)	600 (1112)	201	
(1472)	(1112)		197
(1472)	700 (1292)	197	
(1472)	(1292)		189

NOTES: *Heat 61 — See Table 3 for composition.
**Converted from D.P.H. 10 Kg numbers.

This structure is composed of fine eutectoid and alpha with kappa phase scattered throughout.

Tempering After Quenching Effect

Based on the hardness data for as-quenched samples, two quenching temperatures, 900 C (1652 F) and 800 C (1472 F), were selected for quenching and tempering experiments. Pieces ½-in. by one in. by one in., cut from heat 61 were heated for one hr at 900 C (1652 F). An equal number of pieces were heated for one hour at 800 C (1472 F). After heating, all of the samples were quenched into water. Two pieces from each quenching temperature were then tempered for one hr at 400 C (752 F), two at 500 C (932 F), two at 600 C (1112 F) and two at 700 C (1292 F). After tempering was completed, one of the samples from each tempering temperature was quenched into water and the other piece cooled in air.

Hardness measurements made on each piece are listed in Table 5. Maximum hardness resulted from tempering at 400 C (752 F) for both 800 C (1472 F) and 900 C (1652 F) quenching temperatures. With increasing tempering temperatures, the pieces showed lower hardness values. For the same tempering temperatures, the pieces quenched from 900 C (1652 F) had higher hardness. For both quenching temperatures, only a slight difference was noted between the pieces which were air cooled and those quenched from the tempering temperatures.

TABLE 6 — HEAT TREATMENTS USED FOR CAST ALUMINUM BRONZE ALLOY*

Quenching Treatment	Tempering Treatment
900 C (1652 F)—one hr—W.Q.	600 C (1112 F)—2 hr—air cooled
900 C (1652 F)—one hr—W.Q.	700 C (1292 F)—2 hr—air cooled
900 C (1652 F)—one hr—W.Q.	700 C (1292 F)—2 hr—W.Q.
850 C (1562 F)—one hr—W.Q.	600 C (1112 F)—2 hr—air cooled
850 C (1562 F)—one hr—W.Q.	700 C (1292 F)—2 hr—air cooled
850 C (1562 F)—one hr—W.Q.	700 C (1292 F)—2 hr—W.Q.
800 C (1472 F)—one hr—W.Q.	600 C (1112 F)—2 hr—air cooled
800 C (1472 F)—one hr—W.Q.	700 C (1292 F)—2 hr—air cooled
800 C (1472 F)—one hr—W.Q.	700 C (1292 F)—2 hr—W.Q.

NOTE: *Heat 61 — see Table 3 for composition.
W.Q. — Water Quench (tap water)

Mechanical Properties After Various Heat Treatments

To extend the information on mechanical properties after quenching and tempering, tensile properties and hardness were determined after various heat treatments on keel bars of heat 61. A description of the heat treatments is listed in Table 6, and the tensile and hardness values are shown in the form of curves in Fig. 8. Tempering was conducted only at the higher temperatures because it was believed that the extreme hardness which resulted on tempering at 400 C (752 F) and 500 C (932 F) would be accompanied by brittleness.

Consistent with the hardness data after quenching, the pieces quenched from the highest temperature and tempered at the lowest temperature had the highest yield strength, highest ultimate tensile strength and highest hardness, but the lowest percentage elongation. This same pattern applied for each tempering temperature; that is, the strength is greatest but the ductility lowest for the highest quenching temperature. There is some overlapping in values, however, if a comparison is made between bars which were quenched and tempered at different temperatures. No significant difference was noted between the material quenched or air cooled from the tempering temperature.

Based on the tensile test results shown in Fig. 8, it was decided to use the following heat treatment for the alloys described in Table 1 and discussed earlier: 850 C (1562 F) for one hr, water quench, 700 C (1292 F) for 2 hr, air cool. This treatment seems to provide the combination of high yield strength and elongation. The choice of air cooling from the tempering temperature was made on the basis that air cooling would produce less residual stress than quenching.

SUMMARY

The effect of mechanical properties and microstructure was explored for three elements–aluminum, iron and nickel. Of the three elements, aluminum is the most effective in altering microstructure and properties. With increase in aluminum from 9.5 to 10 per cent, there is a marked decrease in elongation, but a sizable increase in strength and hardness.

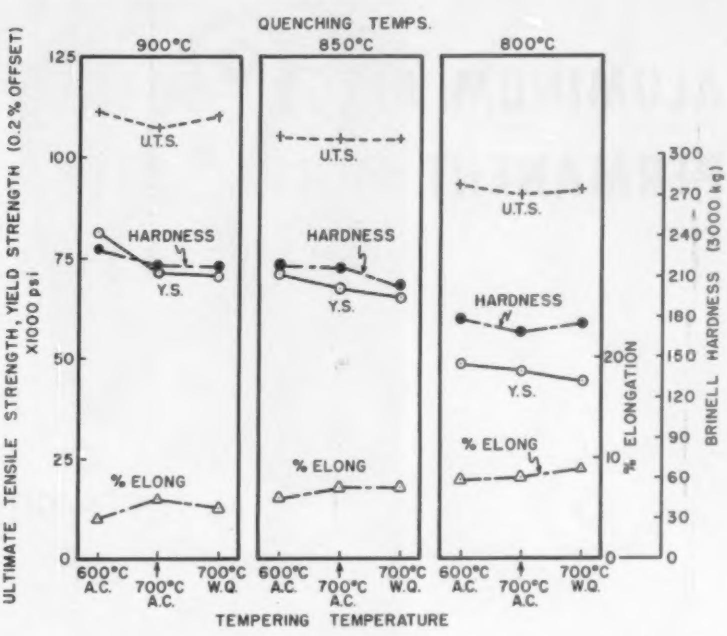


Fig. 8 — Mechanical properties after various heat treatments.

Further increases in aluminum causes the strength and hardness to decrease, but the reduction in ductility is not as great. Increase in strength and hardness with increase in aluminum content are associated with the reduction in the amount of the soft, ductile alpha phase and increase in the strong beta phase and brittle eutectoid phase.

For the range of 3 to 6 per cent iron, the only contribution noted is the increase in hardness upon increasing the iron content. The increase in kappa phase appears to explain the increase in hardness.

Nickel causes a change in microstructure which is analagous to reducing the aluminum content; that is, increasing nickel contents produce a reduction in the amount of beta phase and an increase in the amount of alpha phase. Further, nickel tends to refine the eutectoid phase and thus the tendency to brittleness normally associated with the eutectoid phase is reduced. A combination of high nickel content (5 to 6 per cent) plus high aluminum content results, on heat treating, in an alloy of high strength with usable ductility so far as structural applications are concerned. Similarly, an alloy with lower aluminum content, 9.5 to 10.5 per cent, has higher yield strength with good ductility if the nickel content is increased to a range of 5 to 6 per cent.

All the alloys studied, except alloy 22, responded to heat treatment; that is, yield strength, tensile strength and hardness were increased and elongation was decreased. From an examination of the microstructure after quenching, it can be reasoned that the amount of martensitic phase produced on quenching is the most important cause for changes in properties on heat treatment.

By various combinations of quenching and tempering temperatures, it is possible to produce different strength-ductility combinations although one must be sacrificed to obtain the other. For a given quenching temperature, the choice of tempering temperature will govern the properties. The higher the temperature the lower will be the hardness and strength and the greater will be the elongation.

Two considerations govern the choice of quenching temperature:

1) The possibility of severe grain growth.
2) The resultant ductility-strength combination.

The first item was not explored in this study. Higher quenching temperatures produced higher strength but lower ductility for the same tempering temperature. It is believed that the higher ductility is a result of the greater amount of alpha which exists on quenching from lower temperatures. For the heat treatments chosen, there is no significant difference whether the material is quenched or air cooled from the tempering temperatures. One can select air cooling to avoid unnecessary residual stress. A study of the microstructures of air cooled material reveals why it is necessary to avoid heating to within the eutectoid range, since the samples air cooled from 600 C (1112 F) and 500 C (932 F) showed almost continuous areas of eutectoid phase.

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ALUMINUM ALLOY 356+BE PERMANENT MOLD CASTING

Centrifugal force effect on mechanical properties

by A. J. Iler

ABSTRACT

A study was made, in connection with an Air Material Command R & D contract, conducted by the author's company (Contract AF 33(600)-38450), to determine the effect of forces applied by the permanent mold centrifuge on mechanical properties of aluminum alloy 356 + Be. Using a special mold castings were produced employing various centrifugal pressures. Coupons were cut from these castings from areas related to the feed and chill. These were radiographed, photomicrographed and tensile tested.

This paper discusses an analysis, concluding that superior properties obtainable by use of the centrifuge significantly exist only when coupled with configurations difficult to achieve by other methods without practices deleterious to casting integrity.

INTRODUCTION

Considerable interest has been focused on high tensile properties produced in castings made by the permanent mold centrifuge method. Fins for various missiles are currently being made by this method with tensile properties consistently higher than could normally be obtained by other means. Why there should be higher properties has been a subject of conjecture and speculation.

The centrifuge has been a necessary implement for producing this hardware. Some of these missile fins taper on the trailing edge to 0.050 in. thickness, which would be difficult to achieve by any other means and still produce the high tensile properties required. It is obvious that the mechanics of this method perform certain functions known to enhance elevated properties in castings. These include a faster chill, higher thermal gradients in the solidifying casting and cooler pouring temperatures.

These factors can easily be induced in statically poured permanent mold castings with various expedients used by the founder by application of chills or heat to specific areas of a mold, but the hydrostatic pressures of a static mold are not great enough to fill large areas of thin section.

It is the opinion of many foundrymen that these factors are solely responsible for higher properties achieved. However, there has remained the question of whether the centrifugal force actually had a direct influence on grain structure or homogeneity.

To investigate this possibility, a mold was made for the centrifuge which would produce castings whereby this subject could be studied without any appreciable influence of other solidification factors.

EXPERIMENTAL PROCEDURE

When a casting cavity is filled with molten metal, the influence of pressure upon it is modified by casting configuration, the rate of chill and whether solidification is progressive toward the riser or sprue. To eliminate these factors a mold was developed (Fig. 1) which produced cast slabs one in. thick by 5 in. wide by 7 in. long. The metal was poured directly into an end riser. The opposite end (the farthest from the axis) was chilled with removable end chills.

A typical composition of the aluminum alloy used was:

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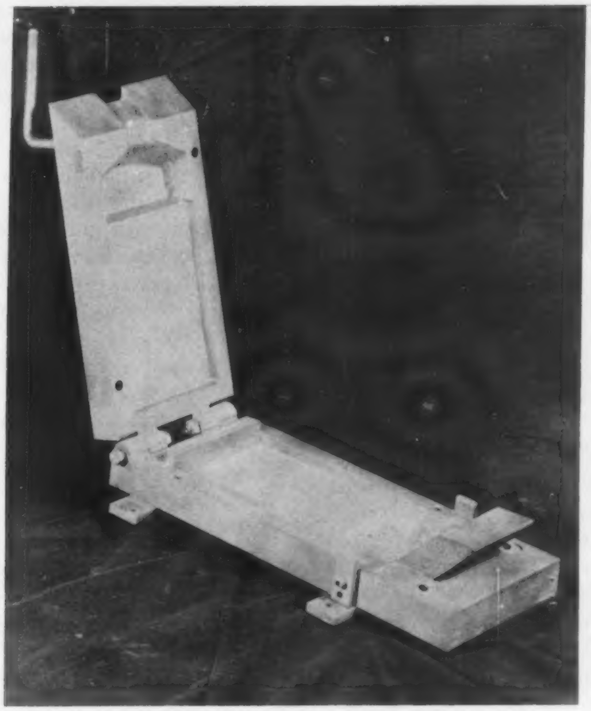


Fig. 1 — Mold developed which produced cast slabs one in. thick × 5 in. wide × 7 in. long.

Zn	Ti	Mn	Si	Mg	Fe	Cu	Be
0.10	0.16	0.04	6.70	0.71	0.13	0.14	0.09

The castings were solution heat treated at 1010 F (542 C) for 14 hr, quenched in 140 F (60 C) water with maximum delay of 22 sec, held at room temperature for 26 hr, then artificially aged at 340 F (171 C) for 6 hr.

The castings produced were thought to have enough volume to allow a free liquid movement during various applications of force and stages of solidification. Also, the solidification nucleated at the mold casting interfaces on the flat sides of the castings would not reduce the effect of centrifugal pressure in any area until the mass solidified.

The pressures exerted by centrifugal force were constant against the solidifying metal. Induced chilling started solidification at the chill end, and the applied force diminished more in proportion to the diminishing radius as solidification progressed toward the turning axis than by cross-sectional reduction.

The formula used to calculate the applied pressure at any given point did not take into consideration solidification nucleated at the mold sides nor the centrifugal arc, but was based upon a noncompressible fluid in a container being constant in cross-sectional area. The formula:

$$p = \rho\,\omega^2 x \left(r + \frac{x}{g}\right)$$

Where:

ρ = (density in lb/in.^{3}).
ω = (angular velocity in radians/sec).
r = (distance in in., axis to casting).
x = (distance in in., casting).
g = (acceleration of gravity in in./sec).

The highest pressure applied (at 275 rpm) amounted to 17.3 psi at the chilled end of the casting. Figure 2 plots pressures at indicated distances

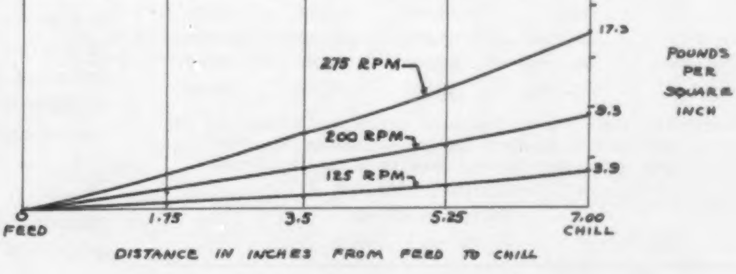


Fig. 2 — Pressure developed by centrifugal force on 1 × 5 × 7 in. slab casting. Calculations based upon fluid mass.

TABLE 1 — TENSILE PROPERTIES (AVG.) VS. CENTRIFUGE SPEEDS

Static, psi	125 rpm, psi	200 rpm, psi	275 rpm, psi
Tensile Strength at Chill End			
52,625	53,610	53,125	52,225
Tensile Strength at Center			
48,975	50,200	48,525	48,275
Tensile Strength at Feed End			
48,850	49,900	50,125	49,000
Yield Strength at Chill End			
46,400	46,900	47,000	45,850
Yield Strength at Center			
45,000	45,830	46,200	44,900
Yield Strength at Feed End			
44,500	44,750	44,975	42,750

from the feed end of the casting which was considered zero pressure, ignoring the slight pressure exerted by the gated metal in the pouring cup. The mold was mounted on a centrifuge in a tilting position, about 20 degrees from horizontal, so that the mold would fill for a statically poured casting.

The chill end was placed 15 in. from axis of rotation. The chills were of iron, like the rest of the mold, but were removable so that they could be held at room temperature until the pouring operation took place. The mold temperature at the time of pouring ranged from 440 to 500 F (227 to 260 C) and the pouring temperature was 1360 F (738 C). Castings were produced under these conditions in sequence at centrifugal speeds of static, 125, 200 and 275 rpm. The castings were heat treated to a T-6 condition.

RADIOGRAPHIC ANALYSIS

X-rays were taken of each casting on fine grained film to show as much detail as possible, but did not reveal an unacceptable quality condition for a normal Class 1A casting. A segregation was noted, however, which may have some significance—the mode of solidification of cast aluminum alloys is the source of dispersed microporosity, they freeze in a mushy state with nucleation occurring nearly simultaneously throughout the mass with solid and liquid existing in intimate contact over most of the casting.

The radiographs indicated that this microporosity dispersion was uniformly sporadic throughout the statically poured casting. However, it rose toward the header in proportion to the amount of centrifugal force until the discernible microporosity in the casting, spun with greatest speed (275 rpm), indicated a small concentration near the feed end of not more than 10 per cent of the mass. The rest of the casting had no apparent discontinuity as revealed by radiography.

The radiographs taken of these castings (Figs. 3a and 3b) give credence to the opinion that centrifugal force contributes to denser castings. This, however, is not necessarily true on typical thin section air frame castings, where solidification is more rapid and the feed by centrifugal force is cut off by freezing of members adjacent to the header (Fig. 3c).

TABLE 2 — TENSILE PROPERTIES PER DISTANCE FROM CHILL (AVG.)

	Centrifugal Speed	Feed End	Center	Chill End
	Static	48,800	48,700	52,400
Tensile	125 rpm	49,800	50,300	53,500
Strength	200 rpm	50,000	48,900	53,200
	275 rpm	48,900	48,200	52,700
	Static	43,100	44,200	45,100
Yield	125 rpm	44,600	45,600	46,900
Strength	200 rpm	46,000	45,900	46,900
	275 rpm	42,500	44,500	45,100

NOTE: The chill end of the mold cavity was located on the centrifuge 15 in. from the axis of rotation; therefore, the rpm speeds may be expressed in surface ft/min as:

125 rpm = 668 sfpm
200 rpm = 1070 sfpm
275 rpm = 1471 sfpm

TENSILE PROPERTY ANALYSIS

Standard 0.505 in. round test bars were machined from three positions in each casting. All were cut transverse to the direction of solidification, and were taken from the chill ends, centers and feed ends.

Figure 4 indicates that highest tensile properties were obtained at the lowest speed used above static (125 rpm), and lowest properties were about equal for both static and the highest speed (275 rpm). However, the scatter band was narrow (not over 3000 psi difference), indicating little improvement in mechanical properties due to increased pressure. Figure 5 shows tensile properties as related to distance from chill.

SURFACE CONDITIONS

The statically poured casting, with negligible amount of hydrostatic pressure, did not reproduce the mold face except in general shape. It was noted, however, that detail of brush marks on the refractory mold was reproduced in greater acuity in proportion to the rate of rotation. At 275 rpm the finest detail completely reproduced on the casting. This could explain why the statically poured casting had slightly lower mechanical properties, since a shrinkage gap between the casting and the mold would affect the rate of heat transfer.

METALLOGRAPHIC ANALYSIS

Metallographic mounts were made of the test bars removed from chill and feed ends of castings produced at four speeds. The coupons were taken adjacent to the fracture so that sub-surface structure could be studied near the center of the gage length, or the center of the casting. Thus, as much as possible the influence of grain refining by quicker chilling at the casting-mold interface was eliminated.

Figure 6 illustrates grain size and the distribution of silicon precipitates. It will be noted that a comparison of photomicrographs shows a similarity in grain size regardless of the rotational speed, whereas

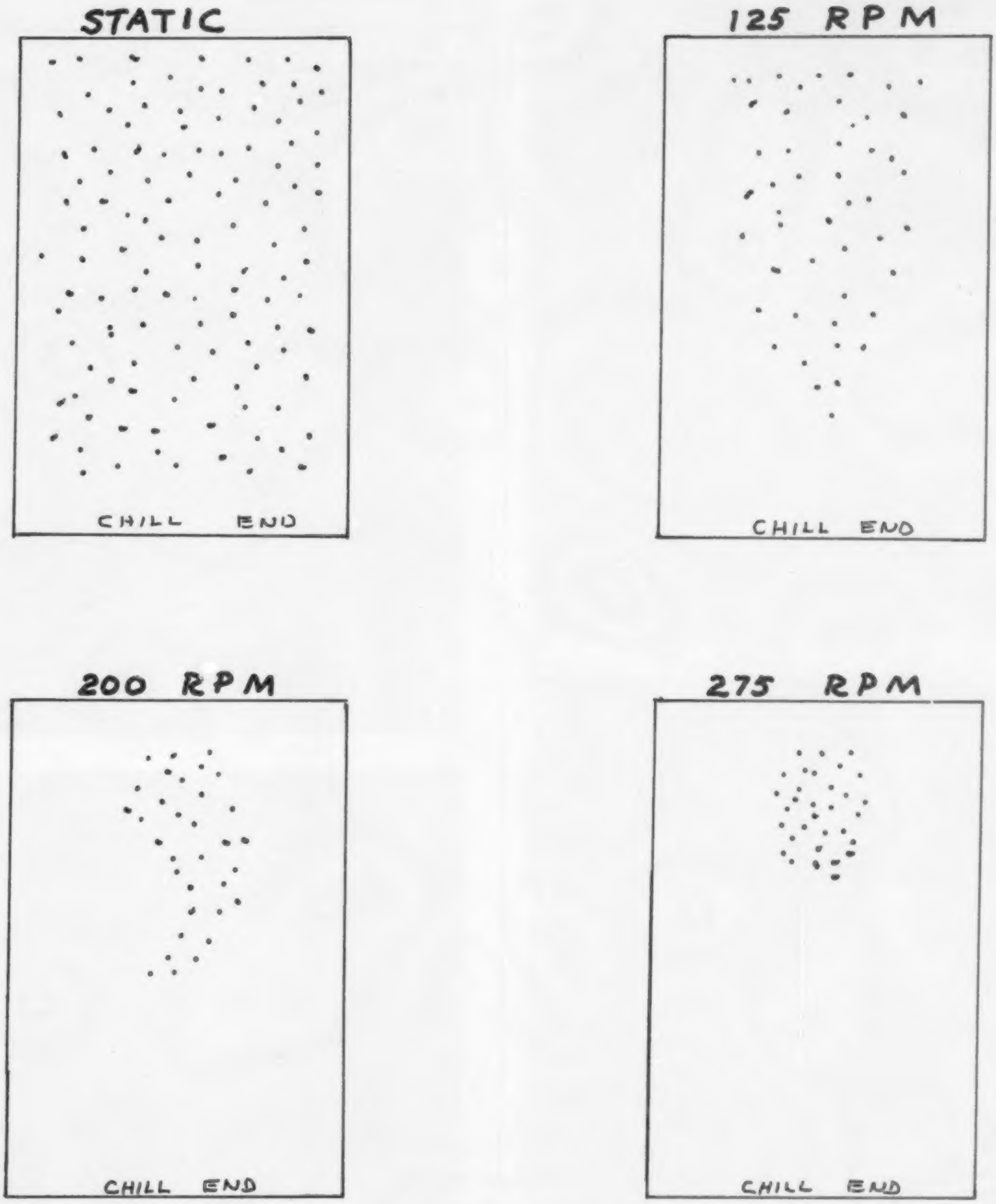
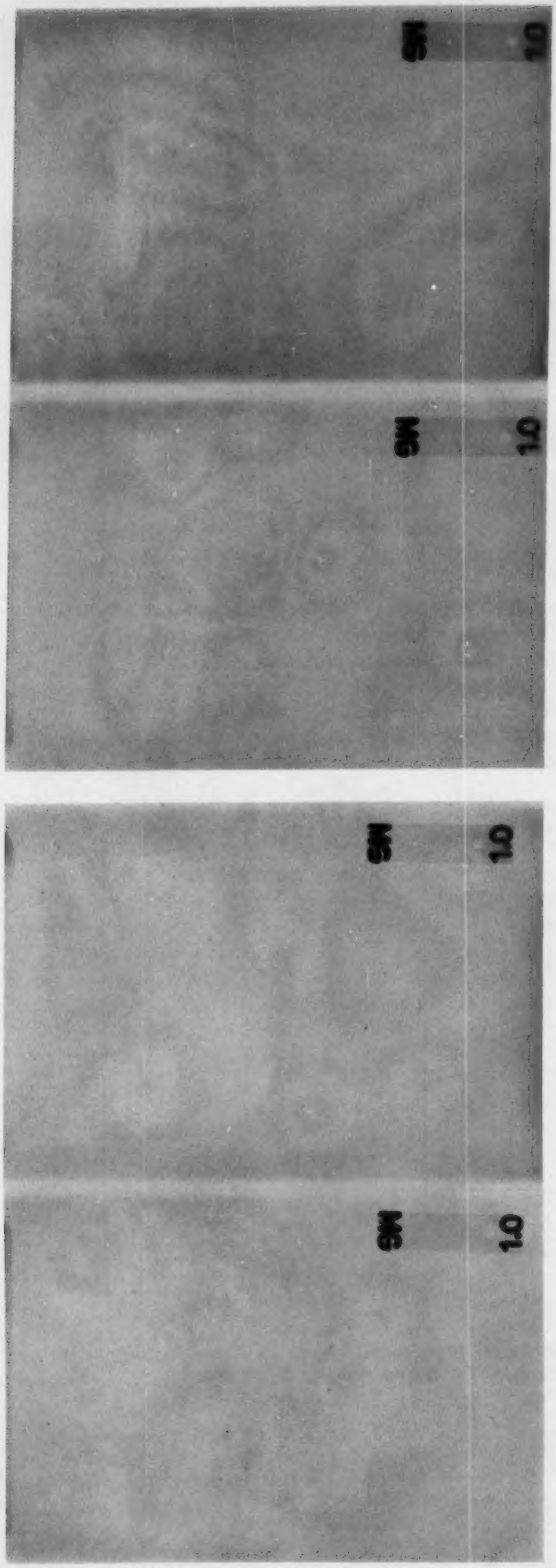
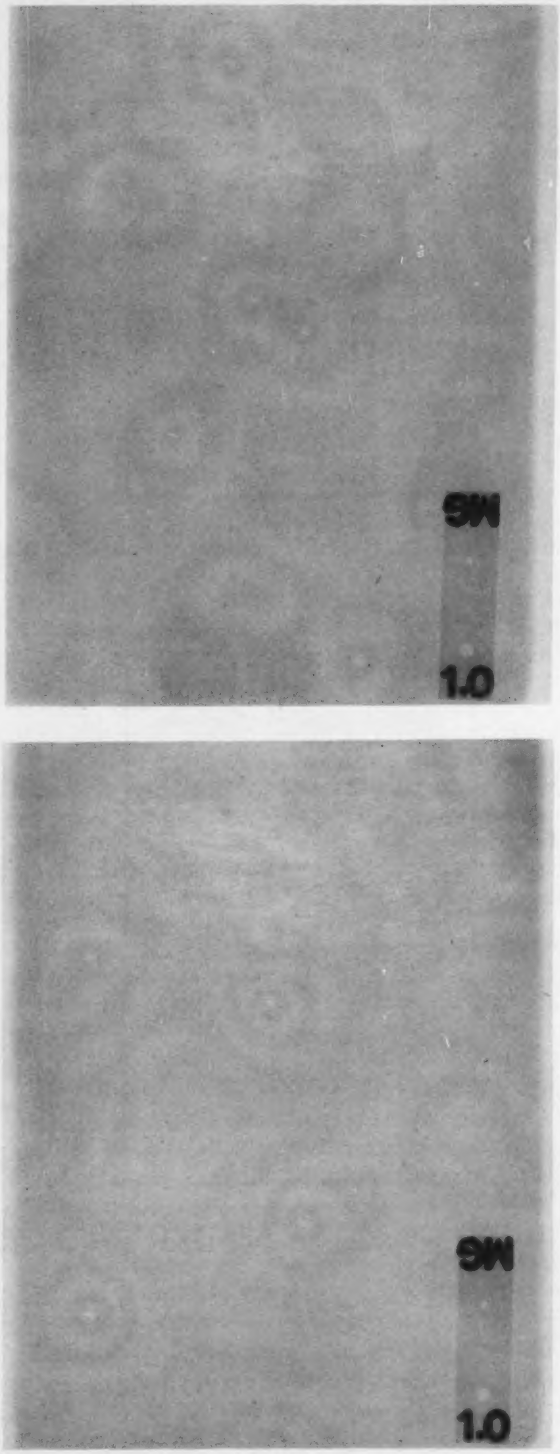


Fig. 3a — Radiographic definition of distribution of solidification voids for centrifugally cast slab of 356 + Be aluminum alloy (see Fig. 3b for actual radiographs).

Fig. 3b(1) — X-ray film, taken of one in. thick slabs 5 in. wide × 7 in. long cast in centrifugal permanent mold at indicated speeds, of magnesium alloy AZ-91. Light areas have least density. *Bottom to top* — no. 16 — static, no. 10 — 50 rpm (950 sfpm), no. 11 — 75 rpm (1425 sfpm) and no. 12 — 105 rpm (1995 sfpm). See also Fig. 3b(2).





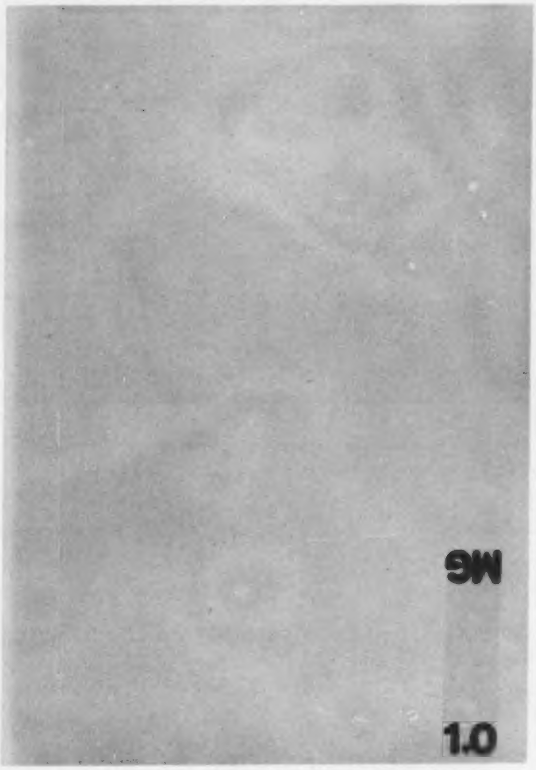
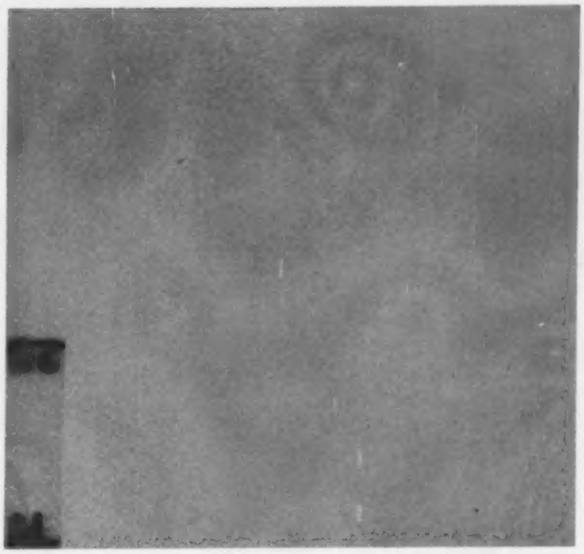
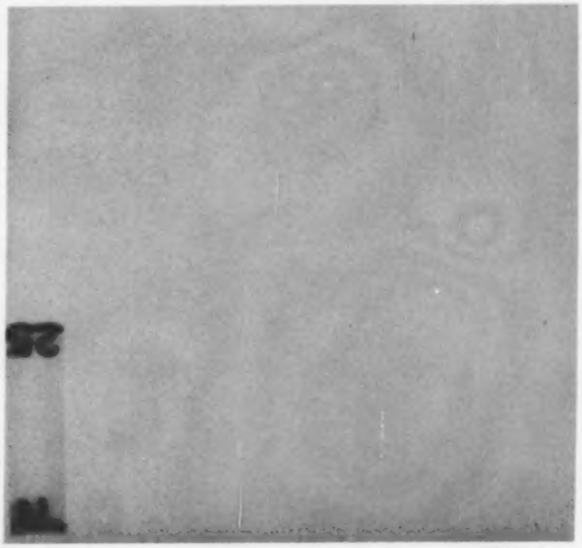
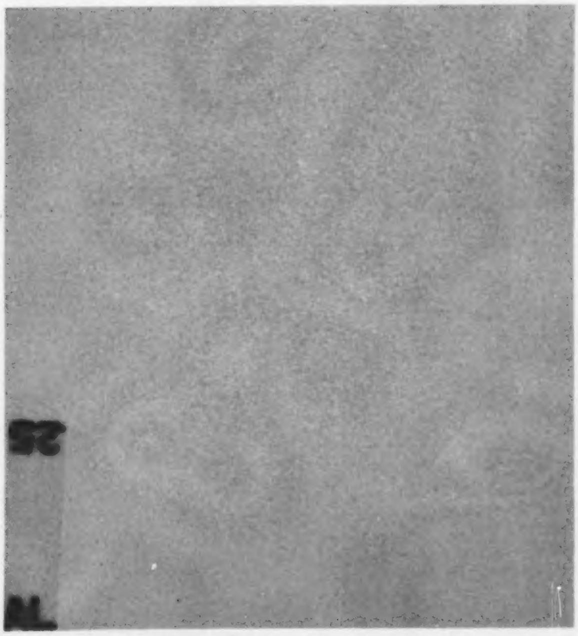


Fig. 3b(2) — X-ray film, taken of one in. thick slabs 5 in. wide × 7 in. long cast in centrifugal permanent mold at indicated speeds, of magnesium alloy AZ-91. Light areas have least density. *Top left* — no. 13 — 140 rpm (2660 sfpm), *bottom, left* no. 14 — 185 rpm (3515 sfpm) and *above* no. 15 — 220 rpm (4180 sfpm).







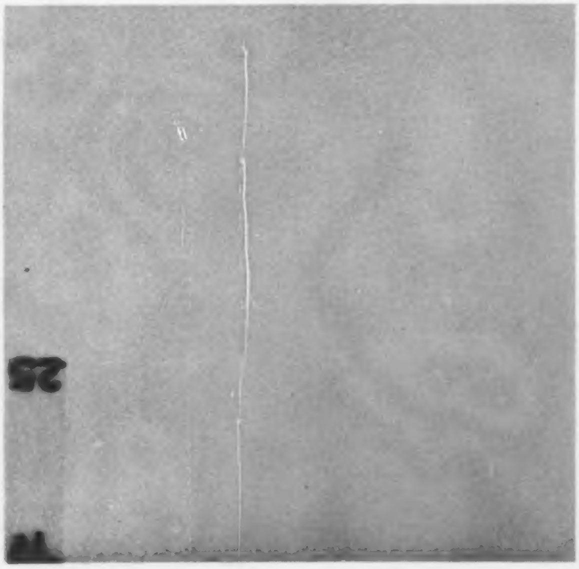


Fig. 3c — X-ray film of aluminum alloy 356 plus Be (compare with Figs. 3a and 3b). *Above* — static pour, feed end; *lower right* — 75 rpm, feed end; *center right* — 140 rpm, feed end; *upper right* — 220 rpm, feed end.

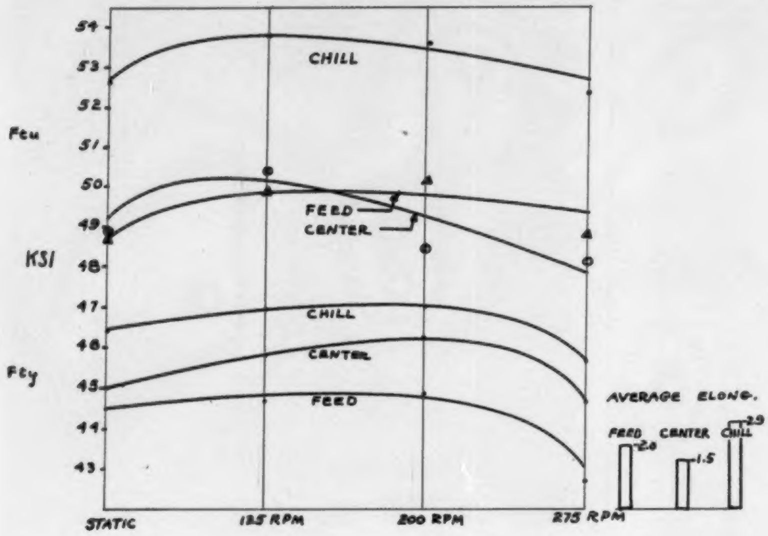


Fig. 4 — Tensile properties vs. centrifuge speeds. Ftu-tensile strength, Fty-yield strength, K51-psi × 1000.

the significant difference is found in relation to the chill or riser ends. The grain is fine and well dispersed at the chill end of all castings, and the grain is coarse at all of the riser ends. There appears to be a slight grain refinement at the chill end of the casting produced at highest speed over that produced statically, but negligible differences are noted in tensile specimens pulled.

CONCLUSION

Any force sufficient to fill the mold rapidly and maintain pressure of the solidifying mass to the mold-casting interface bears an influence on tensile properties as satisfactorily as higher pressures. This is usually done better by conventional usage of gating, the exception being casting configurations with webs too thin for static pouring.

Preferential dispersion of microporosity and improvement in homogeneity noted in this study are greatly minimized in thin wall castings due to the rapidity of solidification. Since this was not significantly effective in tensile properties, it can be disregarded from the standpoint of property improvement.

The advantages gained by use of the centrifuge are to be expressed in terms of hardware rather than metallurgy. Castings are being produced by the industry in configurations impossible to achieve by other means. Thin sections can be filled with good, sound casting. Colder molds can be used, thus providing a more effective chill. Lower pouring temperatures can be used, which may sometimes be evaluated by less gas and more stable chemistry.

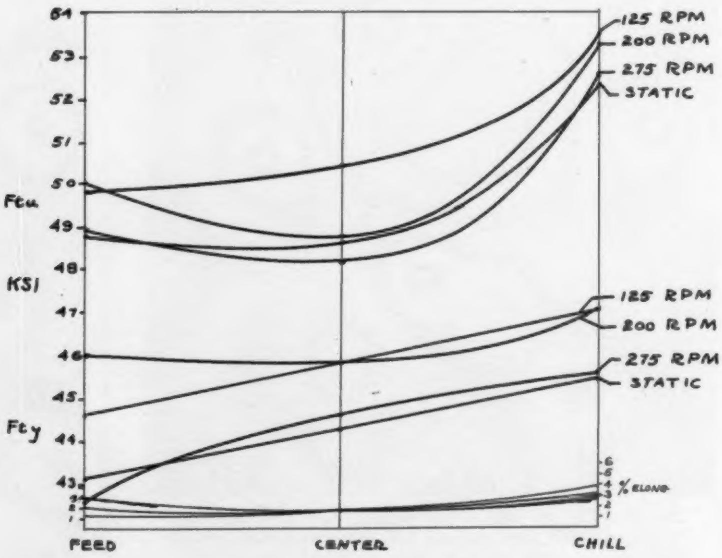


Fig. 5 — Tensile properties per distance from chill. Ftu-tensile strength, Fty-yield strength, K51-psi × 1000.

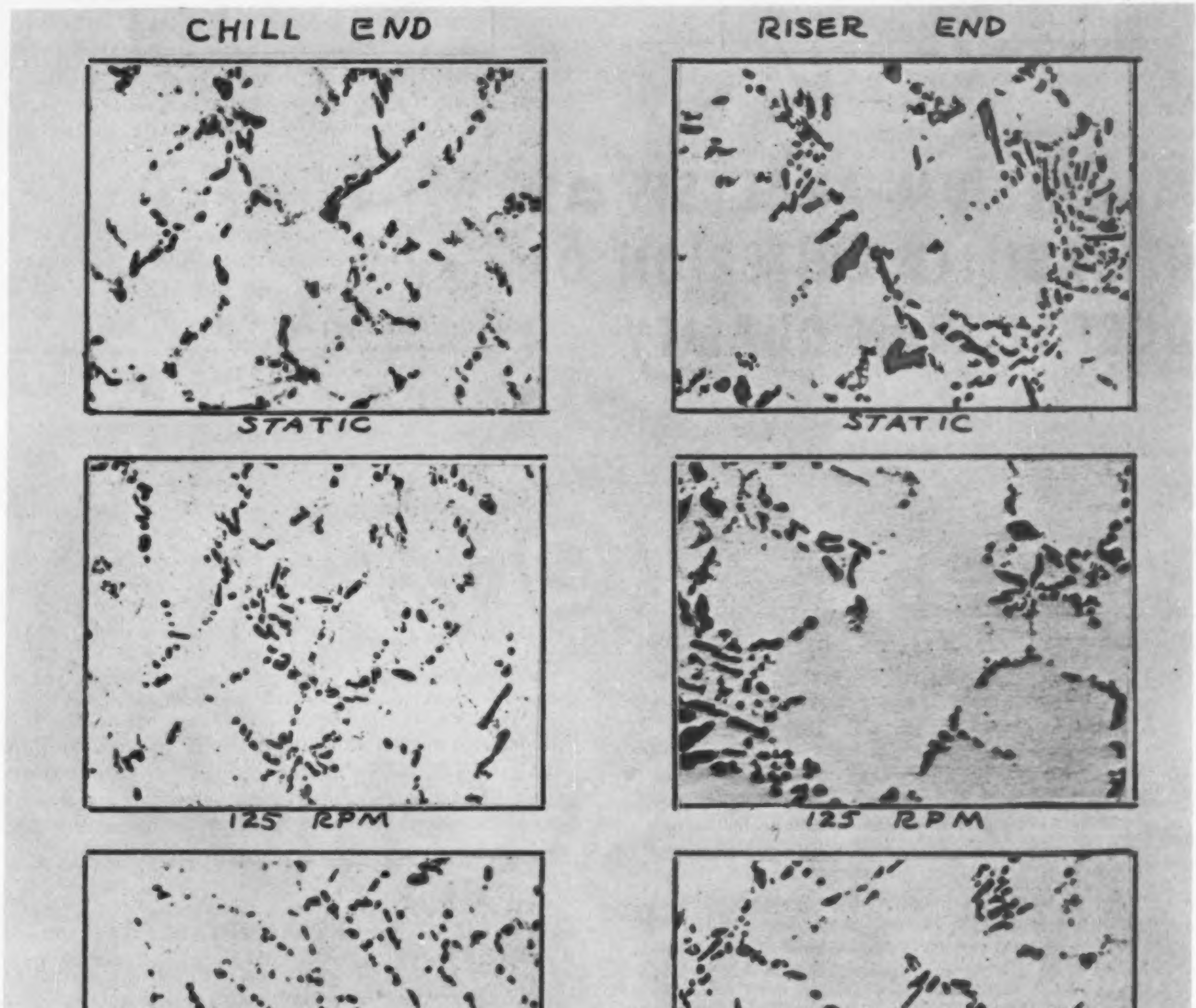


Fig. 6 — Microstructure of centrifugal castings.

MAGNESIUM ANALYSIS AS RELIABILITY CRITERION OF DUCTILE IRON QUALITY

by AFS Ductile Iron Division
Research Committee (12-K)*

ABSTRACT

The intent of this project was to determine with what degree of reliability magnesium analysis could be employed as a control of inspection procedure for ductile iron quality. Nine identical samples were distributed to different laboratories for analysis. As a result it was found that agreement between laboratories on retained magnesium content is, in some cases, poor, and that, at present, the test coupon is a more satisfactory method of controlling quality in ductile iron than magnesium analysis.

INTRODUCTION

Ductile iron owes its properties of high strength with good ductility and a high modulus of elasticity to the nodular or spheroidal shape of the graphite present. Control of the graphite form is largely a function, in the absence of certain subversive elements, of the retained magnesium content. If retained magnesium is to be used for either control or inspection of quality, the small percentage required to produce graphite in the spheroidal or nodular form—on the order of a few hundredths of a per cent—necessitates a high level of accuracy and precision in the analytical technique as well as a high degree of homogeneity in the samples.

In order to determine (1) what agreement in magnesium analysis might be expected between different laboratories and (2) the effect that sample microstructure and possible heterogeneity would have on the analysis for magnesium, the Research Committee of the AFS Ductile Iron Division undertook a project of distributing a number of sets of identical samples to nine different laboratories for analysis. The intent of the project was to determine with what degree of reliability magnesium analysis could be employed as a control or inspection procedure for ductile iron quality.

PROCEDURE

Two commercial analytical laboratories, one research laboratory and six producer laboratories participated in this project. All of the laboratories were accustomed to analyzing for magnesium and all employed some type of spectrochemical analytical procedure. The instrumentation included one type of spectroscope employing visual comparison with a standard; conventional spectrographs using photographic film and direct reading spectrometers. The analytical techniques employed consisted of either direct point to plane sparking of the samples or the sparking of electrodes impregnated or covered with a solution of the samples.

No attempt was made to evaluate or pass judgment on the accuracy of the reported analytical data. Unfortunately, no standard samples, such as those issued for other elements by the Bureau of Standards, are available for spectrochemical analysis of magnesium, and thus each laboratory employs its own calibrated standards. With only the samples cast in green sand, all of which were poured from one 300 lb ladle, was there a sufficient number of identical samples analyzed by each laboratory to permit a statistical evaluation of the degree of reproducibility or confidence limits.

Even with these samples, there could be some doubt concerning the validity of the statistical procedure, since there were only five samples involved

*H. W. RUF, Chairman, D. MATTER, Secretary, A. W. ANDERSON, D. L. CREWS, H. G. HAINES, A. H. RAUCH and W. M. SPEAR.

and since there is a possibility of difference in magnesium content due to segregation or a concentration gradient within the ladle. It was thought, however, that the results might be indicative of the reproducibility and agreement that might be expected.

SAMPLE IDENTIFICATION

The identification and description of the samples employed in this program are shown in Table 1.

TABLE 1 — IDENTIFICATION OF SAMPLES

Sample No.	Size, in.	Type of Mold	Samples per Ladle	Samples from each Ladle
1-5, incl.	$\frac{3}{8}$x1$\frac{1}{2}$x10 (poured horizontally)	Green Sand	5	1-5, incl.
6C-10C, incl.	2 dia. x 1	Copper Chill	2	6C and 6X, 7C and 7X, 8C and 8X.
6X-10X, incl.	1 sq. x 6 (poured vertically)	Baked Core Sand		9C and 9X, 10C and 10X, 11C and 11X.
11-15, incl.	2 dia. x 1	Baked Core Sand	2	11 and 12, 13 and 14, and 15.

NOTE: Samples 1-5 were cast from basic cupola melted iron while the remaining samples were cast from iron melted in an indirect rocking arc furnace.
Samples 11 and 13 were poured from the first part and samples 12 and 14 from the last part of each of two 800 lb ladles. Sample 15 was poured from the first part of a third 800 lb ladle. All of these samples were analyzed on both top and bottom faces and the surface analyzed is identified as *T* or *B*, respectively.

The magnesium contents reported for the various sets of samples are as shown in Tables 2, 3 and 4.

DISCUSSION

The green sand molded samples indicate that the degree of reproducibility or coefficient of variation for some laboratories and procedures is good, but the agreement between the laboratories is, in some instances, quite poor. It would appear from this

TABLE 3 — CHILLED vs. CORE MOLDED SAMPLES

Laboratory	Magnesium Content, %									
	6C†	6X‡	7C	7X	8C	8X	9C	9X	10C	10X
A	—	0.043	—	0.038	—	0.046	—	0.093	—	0.106
C	0.052	0.040	0.059	0.043	0.058	0.043	0.150	0.095	0.163	0.110
D-1	0.076	0.049	0.048	0.050	0.056	0.045	0.093	0.060	0.095	0.076
D-1a	0.052	0.044	0.043	0.042	0.054	0.039	—	—	—	—
D-2	0.038	0.072	0.045	0.048	0.047	0.052	—	—	—	—
D-3	—	—	—	—	—	—	0.096	0.088	0.108	0.106
E	0.057	0.049	0.054	0.044	0.059	0.048	—	—	—	—
G	0.027	0.038	0.022	0.032	0.026	0.024	—	—	—	—
H	0.042	0.049	0.031	0.047	0.039	0.039	—	—	—	—
I	0.050	0.049	0.036	0.046	0.051	0.040	—	—	—	—
Max.	0.076	0.072	0.059	0.050	0.058	0.052	0.150	0.095	0.163	0.110
Min.	0.027	0.038	0.022	0.032	0.026	0.024	0.093	0.060	0.095	0.076
Avg.	0.049	0.048	0.042	0.043	0.049	0.042	0.113	0.084	0.122	0.100

†C = Chilled*
‡X = Core Molded**

*Analysis made on face of samples in contact with copper mold.

**Analysis made on a surface at right angle to the longitudinal axis.

NOTE: D-2 and D-3 represent analysis with the same equipment using two different techniques. Results for 9C, 10C, 9X and 10X represent average of analysis of top and bottom faces in each case.

TABLE 4 — COMPARISON OF ANALYSIS ON TOP AND BOTTOM SURFACE OF INDIVIDUAL CORE MOLDED SAMPLES*

Laboratory	Magnesium Content, %									
	11T	11B	12T	12B	13T	13B	14T	14B	15T	15B
A	0.100	—	0.064	—	0.100	—	0.075	—	0.110	—
B	0.094	0.093	0.070	0.083	0.110	0.111	0.093	0.093	0.105	0.107
C	0.070	0.084	0.053	0.054	0.087	0.089	0.075	0.078	0.103	0.098
D-1	0.065	0.066	0.056	0.055	0.069	0.078	0.055	0.050	0.080	0.075
D-2	0.082	0.085	0.064	0.073	0.096	0.092	0.076	0.068	0.096	0.100
E	0.074	0.095	0.062	0.077	0.095	0.078	0.091	0.077	0.103	0.111
G	0.066	0.068	0.054	0.054	0.070	0.070	0.059	0.058	0.068	0.068
H-1	0.081	0.087	0.061	0.052	0.091	0.087	0.072	0.068	0.097	0.093
H-2	0.088	0.090	0.068	0.066	0.090	0.091	0.075	0.072	0.100	0.110
I	0.093	0.090	0.066	0.064	0.092	0.095	0.073	0.068	0.104	0.110
Max.	0.100	0.095	0.070	0.083	0.110	0.111	0.093	0.093	0.110	0.111
Min.	0.065	0.066	0.053	0.052	0.069	0.070	0.055	0.050	0.068	0.068
Avg.	0.081	0.084	0.062	0.064	0.090	0.088	0.074	0.070	0.097	0.097

*2 in. dia. x one in. high Samples

NOTE: H-1 and H-2 represent analysis with the same equipment using two different techniques.

TABLE 2 — GREEN SAND MOLDED SAMPLES

Laboratory	Magnesium Content, %								Coeff. of Variation	Predicted Range 95% Confidence Limits, %
	1	2	3	4	5	Max.	Min.	Avg.		
A	0.047	0.045	0.047	0.046	0.045	0.047	0.045	0.046	2.17	0.044-0.048
B	0.051	0.050	0.050	0.054	0.050	0.054	0.050	0.051	3.39	0.048-0.054
C	0.044	0.042	0.044	0.042	0.045	0.045	0.042	0.043	3.09	0.040-0.046
D-1	0.048	0.038	0.043	0.038	0.045	0.048	0.038	0.042	10.35	0.034-0.050
D-1a	0.036	0.040	0.039	0.040	0.040	0.040	0.036	0.039	4.44	0.036-0.042
D-2	0.055	0.040	0.037	0.050	0.055	0.055	0.037	0.047	17.81	0.030-0.064
E	0.051	0.048	0.055	0.048	0.052	0.055	0.048	0.051	5.81	0.045-0.057
F	0.034	0.034	0.036	0.038	0.032	0.038	0.032	0.035	6.55	0.030-0.040
G	0.041	0.049	0.047	0.047	0.046	0.049	0.041	0.046	6.52	0.040-0.052
H	0.058	0.047	0.055	0.052	0.054	0.058	0.047	0.053	7.69	0.045-0.061
I	0.051	0.052	0.052	0.051	0.052	0.052	0.051	0.052	1.08	0.051-0.053
Max.	0.058	0.052	0.055	0.054	0.055					
Min.	0.034	0.034	0.036	0.038	0.032					
Avg.	0.047	0.044	0.046	0.046	0.047					

NOTE: D-1 and D-1a are the reported independent observations of two analysts using the same equipment; D-2 represents the results obtained with another type of equipment in the same laboratory.

phase of the program that the green sand molded specimen of this particular dimension shows good uniformity within each sample and among separate samples poured from the same ladle. However, these data represent only one set of samples and one magnesium level and should not be considered conclusive.

Inspection of the data for the chill molded versus core molded samples indicate not only poor agreement between laboratories, but also an inconsistency within a given laboratory on the part played by the molding practice and the microstructure. The comparison of the data for top and bottom of 2 in. dia. x one in. thick core molded samples indicate that some laboratories found no appreciable or significant difference between these two surfaces, while others reported a considerable difference. Again, the agreement between laboratories in some instances was poor.

Consideration of the information gathered in this program demonstrates that, with certain types of equipment and analytical techniques, a fairly good degree of reproducibility can be achieved within a given laboratory and, with a proper sampling procedure, magnesium analysis can be reliable for in-plant control. There remains to be established, however, a relationship between retained magnesium content, the degree of accuracy and precision of magnesium analysis required, and the graphite form before magnesium analysis can be employed to control or assess ductile iron quality.

Some idea of the relationship between retained magnesium content and graphite form can be obtained from a consideration of experience of one of the producers involved in this program. Shown in Table 5 is a breakdown of the results of magnesium analysis in terms of its relationship to the amount of vermicular or stubby graphite, as well as flake graphite. The data represent an evaluation of 964 samples taken from Y-block test bars cast over a period of seven months. These test bars were cast from the first and every tenth ladle following. The results are not used for routine process control—this producer examines a test coupon poured from each ladle treated for control purposes. This producer's specification, on the basis of experience, allows up to 10 per cent vermicular graphite.

TABLE 5 — MAGNESIUM CONTENT vs. GRAPHITE FORM

Mg Range Group, %	No. of Test Bars	Vermicular Graphite: Trace to 10%	Vermicular Graphite: Above 10%	Percentage of Range Group Above 10% Vermicular Graphite
0.010-0.020	4		4*	100.0
0.021-0.025	15	1	14**	93.3
0.026-0.030	17	4	13	76.5
0.031-0.035	37	23	14	37.9
0.036-0.040	60	27	1	1.7
0.041-0.045	86	15	0	0
Above 0.046	745	0	0	0

*Three samples exhibited entirely flake graphite.
**One sample exhibited entirely flake graphite.

The data in Table 5 should not be construed as setting minimum magnesium levels for obtaining essentially nodular graphite. Until such a time as a reliable magnesium standard is established, the magnesium content cannot be employed as a criterion. Furthermore, with the analytical technique used by this producer, the 95 per cent confidence limits for magnesium analysis are considered too wide to permit the use of the magnesium content as a reliable criterion of acceptability. The analysis is used as a check on magnesium recovery and effectiveness.

There is some reason to believe that the minimum amount of retained magnesium required to secure a satisfactory graphite condition may vary with the melting practice or initial sulfur content. There is also some evidence that a change in a given producer's practice could alter the retained magnesium content required and make the analysis for magnesium unreliable as a criterion.

CONCLUSION

The agreement between various laboratories on retained magnesium content is, in some instances, quite poor. It is believed that with a suitable standard and certain techniques and instrumentation reliable and reproducible results may be achieved. However, even with a satisfactory procedure for magnesium analysis, there are other considerations which could affect the reliability of analysis for retained magnesium as a means of controlling and assessing graphite form or ductile iron quality. These other factors are segregation, the effect of sample microstructure and soundness and the possibility of a shift in magnesium level required to obtain nodular graphite.

A producer, by employing the proper procedure and instrumentation, and with consistent sampling, may establish a relationship between retained magnesium for in-plant control purposes and graphite form. A user, however, analyzing castings for magnesium could be misled by segregation in the samples, or by failing to know the minimum magnesium content required to secure the desired graphite form with a particular supplier's practice.

Many producers employ for daily process control the examination with the microscope of either the test coupon devised by the Ductile Iron Research Committee, described in the annual AFS TRANSACTIONS, *vol. 68* (1960) or some form of it. This procedure, when properly applied, is reliable since it reveals directly the graphite form, which is the condition that must be controlled for quality. Control employing magnesium analysis relies upon maintaining the accuracy and precision of an analytical procedure. This is particularly important since small variations in analysis assume great importance where an element is present initially in only small percentages. The equipment that will give the necessary accuracy and precision along with the speed required is elaborate and expensive.

The Committee feels that the examination of a test coupon is, for the present, a more satisfactory method of controlling the quality of ductile iron. The National Bureau of Standards is in the process of developing a standard sample, No. 342, with a low magnesium content as currently used for producing ductile iron. When this is available, magnesium analysis will become more reliable.

HIGH STRENGTH STRUCTURAL STEEL CASTINGS FOR AEROSPACE APPLICATIONS

by W. R. Roser

ABSTRACT

Steel castings offer a definite advantage to the designer of aerospace vehicles in the form of high strength and attendant weight and volume savings. The author's company's designers have utilized these advantages in the design of a supersonic trainer. Steel castings used on the trainer have been a problem from the standpoint of mechanical properties, and the causes of these problems appear to originate in the foundry. Controls in the foundry are required and will be more important as the alloys become more complex and the casting requirements more stringent. Foundrymen need to re-evaluate their position and up-grade their product in order to get their fair share of business from the aerospace movement.

INTRODUCTION

In order to conquer one of the last and most challenging frontiers left to man – that of outer space, and to build aircraft to fly higher and faster than ever before, the Design Engineer has turned to numerous materials, processes and designs to lighten and improve the capability, performance and reliability of the numerous complex components making up the system, whether it be aircraft or missile. Materials engineers are working constantly to improve known materials and alloys, and to discover new materials which can fulfill these requirements.

A great deal of work and money is being expended on materials such as beryllium, which shows a great deal of promise because of its high modulus of elasticity and low density. However, the metal has a large number of problems to be solved before it can take its place as a common structural material.

STEEL INVESTMENT CASTINGS

Steel castings, especially those produced by the investment process, can fulfill the requirements for lightweight components. Even though steel is a dense material, unnecessary material not removable in machining is eliminated. Parts entirely too complex to be "hogged-out" and remain light weight or produced without elaborate welding, brazing or some other means of joining, can be cast with comparative ease. Entire assemblies can be made one integral part. The possibilities are great. Steel also offers good strength-to-density ratios and good strength-to-volume ratios, as well as moderately high-temperature strength.

In short, theoretically at least, steel castings offer great promise for the aerospace industry. It might be well to interject the thought at this point that the production cost savings attendent to high volume production are not taken into consideration, due to the fact that high volume production will probably never be achieved in this industry. The design-structural-materials engineering team at the author's company made good use of 17-4PH investment castings in the design of the supersonic trainer currently in production for the Air Force.

The figures show some typical illustrations of the castings utilized in this trainer. Figure 1 is one of the cast aileron hinges. Figure 2 is a canopy down-lock housing. The structural use of these castings dictate the necessity for a high degree of reliability and strength. There are approximately 20 different

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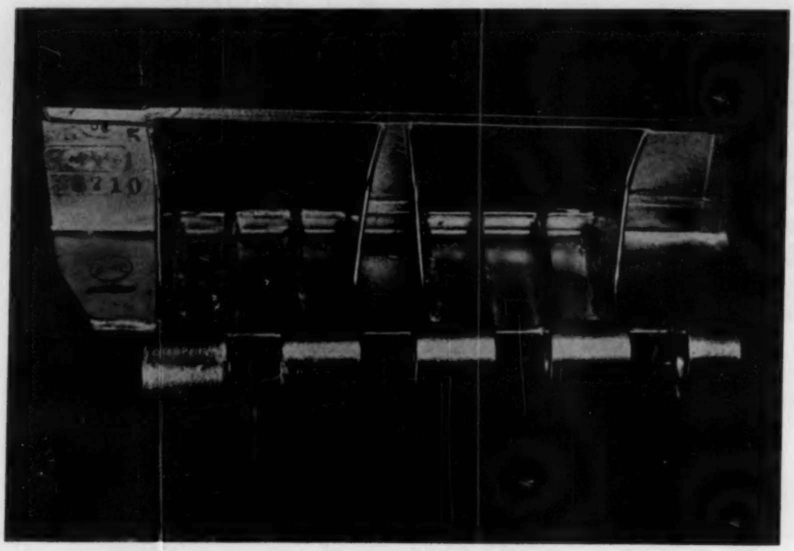

Fig. 1 — Cast aileron hinge.

17-4PH steel investment casting designs utilized in the aircraft.

It nearly became necessary, however, to abandon the entire 17-4PH steel castings program. Castings were tested early in the program and found to be lacking in ductility, and it became necessary for the company to investigate the causes. The table is an example of the typical mechanical properties obtained on several lots of castings from as many foundries. It should be noted that these were not only specimens taken from castings, but keel-gated, separately-cast, test bars.

Test Bar	Yield Strength, psi	Ultimate Strength, psi	Elong., % in 1 in.	Red. of Area, %
1	181,200	195,600	2.0	2.0
2	169,300	183,000	2.0	—*
3	175,500	195,800	2.0	3.0
4	168,300	201,200	1.0	2.0
5	——**	180,400	0	0
6	167,400	177,100	0	—*

* Flat Bar from casting.
** Failed before 0.2% offset yield.
Remainder — round, keel-gated test bars.

DUCTILITY PROBLEM

At this point it might be well to review the reasons believed to be responsible for lowered ductility. The first and most difficult to eliminate is the delta ferrite pattern, shown in Figure 3. This condition is believed to be caused by improper chemical balance or rate of solidification. The second is microshrinkage, as illustrated in Figure 4. These conditions do not noticeably detract from the strength of the casting unless present in large amounts, but severely lower the ductility. Another condition not shown which causes lowered strength is that of retained austenite. This is caused by out-of-specification chemistry, such as high nitrogen or carbon. This condition was rarely encountered in the castings purchased by the author's company.

In the face of the poor showing which the steel investment castings were making, it became necessary to rectify the situation to build airplanes. Had it not been for the fact that it would have been extremely

Fig. 2 — Canopy down lock housing.

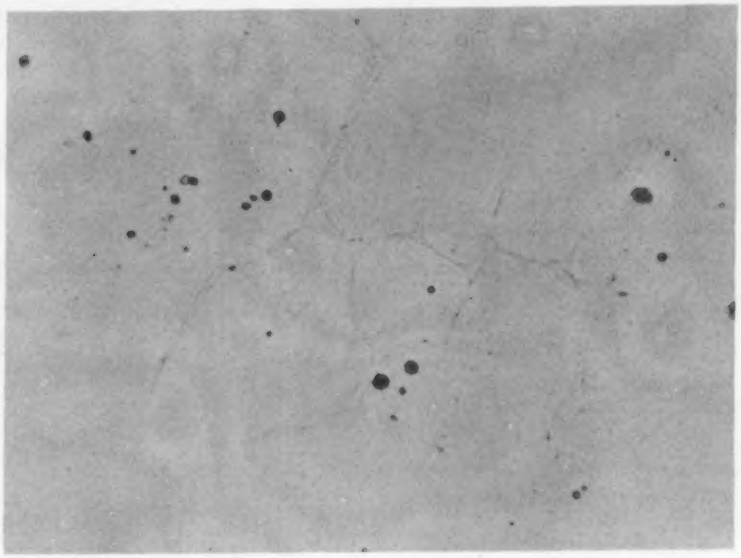

Fig. 3 — Delta ferrite pattern in 17-4 PH steel with elongation less than one per cent. This pattern is most difficult to eliminate. 500 ×.

costly to change to "hogged-out" parts (and disadvantageous from the weight penalty associated therein), the castings would have most certainly been abandoned. In order to assure that the castings were usable, it became necessary to issue a supplementary document to the specification.

This document provided a means of obtaining as much as possible an insight into the properties of the casting without imposing impossible controls on the foundry's operation. A provision was made whereby a foundry must furnish proof in the form of cast test bars from three foundry heats of material that it is able to handle the alloy. This seems like a simple requirement, but the results were surprising. There were foundries incapable of casting a passable test bar. There are also requirements for test bars cast within each flask of castings for purposes of verification of melt quality.

This is done principally because of the small foundry heats used in investment foundries, and the possible lack of uniformity from heat to heat. In some of these foundries, one heat is a single casting. The properties of 17-4PH appear to be rather sensitive to mold and pouring temperatures; and since it is difficult to control these exactly, the integrally cast bars provide a good indication as to whether the metal in the casting has been properly processed.

TENSILE TESTING

At the outset of a foundry's production of a particular casting, one casting out of each production lot is cut up, and tensile tests made in order to assure that the properties in the casting are satisfactory as well as the correlation of the integrally cast bars to the casting properties. In addition, castings are peri-

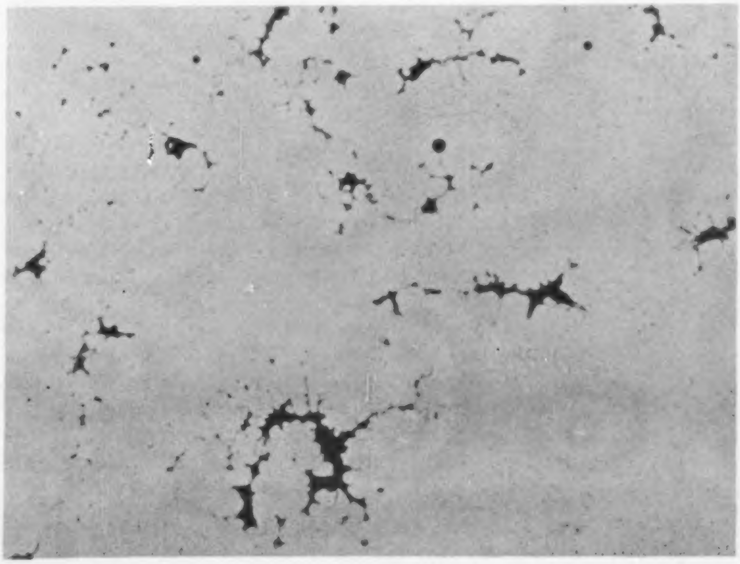

Fig. 4 — Microshrinkage in cast 17-4 PH steel with elongation less than one per cent. 100 ×.

odically cut up and tested. Needless to say, all of this testing is quite an expense. Nevertheless, it has been shown to be invaluable in preventing parts of inferior quality from finding their way into airplanes. When the failure of a single casting could cost the life of the pilot and/or the airplane, the comparative cost is infinitesimal.

This additional testing has made buying of castings more than a difficult job, due to the fact that although the strength requirements for these castings are not in excess of current specification requirements, the company insists that they are obtained and tests to make sure they are. The result is a higher than usual rejection rate.

As was previously stated, 17-4PH steel in the cast form is a rather difficult alloy in which to get the optimum properties. Chemical composition, pouring and mold temperatures and heat treatment are all of great importance to the properties obtainable in the final product. What is being done to solve the problems of the alloy?

REVISED CHEMICAL COMPOSITION

The producers of master heat materials have worked to come up with a revised chemical composition to assure that castings achieve the required minimum strength and ductility. It is unfortunate that this is but half the answer. At least two major aircraft and missile producers have complained that the problem of low ductility still exists. Therefore, it must be supposed that the answer lies in a place other than the chemical composition. This leaves foundry practices.

However, let us not criticize only the foundry. It is the consumer that has fostered the "good enough" philosophy in the foundry by not testing adequately and forcing the quality up. "Good enough" as applied to defroster knobs cannot be applied to aeleron hinges. The uses to which steel castings have been put in the past probably did not warrant the high testing costs; but in the present, and certainly in the future, reliability is the foremost requirement, and the quality of steel castings must be up-graded.

Properties of random samples of 17-4PH steel castings tested at the author's company have far exceeded the specification, and were found to be as good if not better than the wrought material. Such an experience makes one wonder why this is not done more often, rather than have one lot fall into the high strength, high ductility category, and the next be a dismal failure in one or both respects.

PROCESS CONTROL

The answer is control. Control upon control is required from virgin metal through the last heat treating and cleaning operation. Little can be left to chance. In conversation with foundrymen, they have admitted this readily but qualify it by saying, "The controls which are required to give you what you want are too expensive for our operation to make a profit." Unfortunately, they are right. Most foundries are producing castings for the aerospace industry only as a side line, and the mainstay of their business is commercial production.

The foundry industry is an extremely competitive business, and in order for a foundry to be competitive its production costs must be cut to the bone. Unfortunately, the answer to this problem of economics is beyond the comprehension of this engineer. It has served, however, to make competition stiffer for the foundries, since some companies in the aerospace industry have opened their own foundries so as to get what they require from castings. Others have designed away from castings.

Control of the process from pattern to cut-off is paramount in achieving the desired end result. It is quite probable that the cost of instituting these process controls might not be as high as one might think. In order to institute controls, it is necessary to isolate the variables and to determine which are major in influence on the end result and which have only a minor influence. Control those which have been found to have the major influence. Through the trial and error method only mediocre high-cost results will be realized. Professor Howard F. Taylor of Massachusetts Institute of Technology summarized it well by stating, "It is not heretical nor unfair to observe that metal casters, taken as a group, have clung far too long to the belief that knowhow and experience are superior to science and technology."*

Experience and knowhow are important, but the technical, engineering approach must be combined with them if the casting requirements of the aerospace age are to be met. It is impossible to talk in terms of aerospace requirements without advancing the foundry technology. Reliability is the paramount requirement for success in any of the present aerospace products, and will be more so in the future.

CONCLUSION

Foundries are going to have to accept the fact that the day of mass production of aircraft is rapidly fading, and with it large orders of castings. The future orders will be small, and the requirements will be tough to meet. It will also be necessary to resell many people on castings due to experiences they have had in obtaining what was required and actually promised in their part. Many designs which could be castings are being made by other means.

The fact remains that castings offer one of the biggest advantages to the Design Engineer to get the shape he requires without extra poundage from unnecessary metal impossible to remove by machining. It should be noted that many of the highest strength, high temperature alloys can only be produced in a usable shape by casting, since they are so tough they cannot be forged or rolled.

However, they will not be used unless they are produced to exacting quality standards. It is up to the casting industry to provide the aerospace designer and builder one of the most promising tools to get off the ground with, and that is a sound reliable casting.

**Foundry* (Sept. 1960).

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AFS CONVENTION NEWS

DETROIT, MAY 7-11

Signing of AFS-Sponsored Ground Rules At Detroit Marks New Era for Shows

Detroit has taken one of the most progressive steps ever taken by a major convention city with the signing of AFS-proposed ground rules.

Representatives of the city, the giant new Cobo exposition building, all major labor unions involved, and the American Foundrymen's Society met July 6 to jointly sign an agreement covering a set of basic ground rules for installing, dismantling, and operating expositions.

The ground rules automatically become part of the contract between Cobo Hall and AFS for its exposition scheduled in the hall May 7-11, 1962. It will be the largest industrial exposition yet for the new hall and will be the first time in 10 years that the International Foundry Congress, with a world-wide attendance of metalcasting producers, will be held in this country.

Representing the City of Detroit at the signing were Mayor Louis C. Miriani and Steve Kish of the Civil Center Commission (Cobo Hall). Representing the unions were Tom McNamara, secretary, and Daniel J. Diamond of the Detroit Building Trades Council, and L. M. Weir, secretary of the Carpenters Union. Representing the exhibitors were Einar Borch, president, Foundry Equipment Manufacturers' Association; AFS President A. L. Hunt, AFS National Directors Tom Lloyd and Claude Jeter, AFS General Manager Wm. W. Maloney; Cliff Hockman, Honorary Chairman of the Detroit Convention Committee; Jess Toth, Chairman of the Detroit Convention Committee; and Ray Sutter, Chairman of the Detroit Chapter.

General Rules and Regulations

Each craft actively engaged in the set-up and dismantling of the specific show shall assign not more than one steward and one business agent to the specific show.

Each business agent properly representing his craft shall be available to settle any dispute arising during the entire period of the show, ranging from set-up through dismantling. Should the regularly assigned business agent not be available, his organization may appoint a substitute to act in his behalf.

The steward, or business agent, shall call the exhibitor's attention to alleged infractions of work rules, and such infractions must be immediately brought to the attention of the city's floor personnel. Exhibitors, likewise must report their complaints, in writing, to the city's service desk in order to effect proper settlement.

All contractors, show and building personnel, regardless of identity, must observe show rules with respect to wearing identification badges which are furnished by contractors, show or building officers, in order to maintain proper show security and positive identification of personnel.

No exhibitor or contractor shall be required to engage labor on a stand-by basis, unless such service is requested by the exhibitor or contractor. However, it is to be understood that the jurisdiction of such work shall be recognized by the exhibitor or contractor to the extent that the work assignment, if any, shall not be given to another classification.

Material Handling

Designated space, approximately 100 feet east of the inside walls of Halls A, B, C and D shall be labeled as extended dock area to the extent that space for such use is allocated by show management.

Exhibitor shall be permitted to drive his own, or his company-owned automobile or station wagon into the extended dock area.

Exhibitor shall be permitted to carry to his display area those items which can normally be carried by hand, by one man, without the use of fork-lifts, hand trucks, dollies or other handling equipment, providing same can be accomplished within a reasonable time not to exceed 15 minutes.

Unpacking Material

Light objects may be unpacked and placed on display locations by the exhibitor, provided that no tools commonly associated with the trades are used for such purpose.

Rearranging of display merchandise may be accomplished by the exhibitor without restriction after his original display set-up has been completed, provided no equipment or tools are necessary.

Maintenance of Exhibits

Exhibitors shall be permitted to perform minor repairs to an exhibit provided that same can be accomplished in a period of approximately 15 minutes.

At the signing of the show ground rules were, left to right; Wm. W. Maloney, AFS General Manager; Einar Borch, President, The Foundry Equipment Manufacturers Association; Jess Toth, Chairman, AFS Convention Committee; Ray Sutter, Chairman, Detroit Chapter; Al Leggat, Manager, Cobo Hall; Herb Boning, Executive Vice President, Detroit Convention Bureau; Al Hunt, AFS President; Steve Kish, Civic Center Commission; Mayor Louis Miriani, City of Detroit; Cliff Hockman, Honorary Chairman AFS Convention Committee; Claude Jeter, AFS Director; Tom Lloyd, AFS Regional Vice President and Director.

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Circle No. 144, Pages 133-134

NEWS and VIEWS

Chairmen Meeting Highlights
Stress Controls at Penn State

AFS Technical Program Wins Tax Exemption by New U.S. Ruling

Ruling Allows Expansion of Society's Technical Service to Entire Industry

An AFS comprehensive plan for industry-wide technical progress has moved one step closer to realization. The program has been conducted on a restricted basis with its expansion hinging on a government tax ruling. Now this hurdle has been cleared.

The AFS Training & Research Institute has been declared exempt from Federal income tax by a ruling of the U. S. Treasury Dept. dated July 11. The Institute is now classified as exempt under Sect. 501(c)(3) of the 1954 Internal Revenue Code as an institution organized and operated exclusively for educational and scientific purposes.

At this time, unlike many European countries, there are no known facilities in America, devoted exclusively to cast metals instruction and research, similar to those in England, Germany, France, Spain, Sweden, Russia, and other countries. The National Training Center included in the program would fill permanently the growing needs of a progressive industry.

A Four-Year Effort

This Treasury Dept. decision climaxes efforts extending over four years to obtain a tax exemption status similar to that of many other organizations with similar purposes. The Institute was created by AFS Board resolution in November, 1956, a Trust agreement was signed in December, 1956, and application for exemption was filed a year later. In March, 1958, the application was denied. The current ruling revokes that denial and grants T&RI full tax exemption.

The AFS Institute is now in a position to develop fully the 5-point program originally approved. A part of the program has been operational for some time, but the remainder could not be undertaken without full tax exemption. Contributions to organizations exempt under Sect. 501 (c) (3) are deductible by donors, and bequests, legacies, transfers or gifts are deductile by donors for Federal estate and gift tax purposes.

Included in the program are:

1. Sponsorship of basic research on cast metals projects proposed by AFS research committees.

2. Expansion of technical field services through regional training courses. Nearly 60 training courses have already been presented in 10 foundry centers with over 1700 men from more than 600 separate plants attending. Regional courses have been given in Ontario, California, Alabama, Tennessee, Illinois, Indiana, Texas, Michigan, and Wisconsin.

3. Holding of Foundry Instructor Seminars for high school and vocational school teachers. Four seminars have been presented thus far.

4. A broad program of scholarships. A $50,000 donation available since 1956 could not be accepted until now.

5. Contemplated construction of a National Foundry Training Center building adjoining the AFS headquarters building in Des Plaines, Ill. This building is to be designed, equipped, and staffed to provide intensive and continuous training courses for foundry personnel. Building plans and detailed specifications have now been completed, and additional adjoining land acquired for off-street parking.

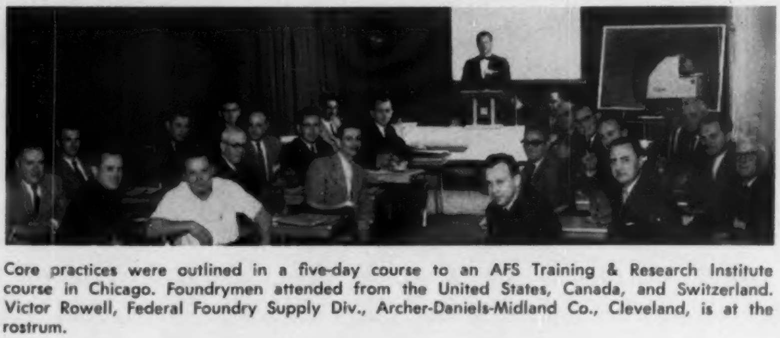
Success with all initial stages of the T&RI program has lead the Institute Trustees to recommend that the AFS Board proceed with construction of the Foundry Training Center. By action in August, 1959, final decision on construction must be made by the Board as a whole.

Schedule Two Regional Meetings in September

Two AFS Chapter-sponsored regional conferences will be held in September. The East Coast Regional will be held Sept. 22-23 at the Statler Hilton Hotel in New York. The Missouri Valley Regional will be held Sept. 21-22 at the Missouri School of Mines, Rolla, Mo.

The Missouri Valley Regional will introduce an educational shop course and demonstrations of non-destructive testing. Robert C. Kane, Midvale Mining & Mfg. Co., is general conference chairman. Sponsoring chapters are St. Louis, Mo-Kan, Tri-State, and the Missouri School of Mines Student Chapter.

Steel, gray and ductile iron, alumi-



Core practices were outlined in a five-day course to an AFS Training & Research Institute course in Chicago. Foundrymen attended from the United States, Canada, and Switzerland. Victor Rowell, Federal Foundry Supply Div., Archer-Daniels-Midland Co., Cleveland, is at the rostrum.

Artist's plan for National Foundry Training Center building adjoining present AFS Headquarters (left) in Des Plaines, Ill. Construction of the building had been deferred pending income tax exemption.

num and magnesium, brass and bronze, and malleable sessions will be held. R. B. Fischer, Ingersoll-Rand Co., is general conference chairman. Sponsoring Chapters are Metropolitan, Philadelphia, and Chesapeake.

Other regional conferences to be held in 1961 are:

Ohio Regional **Oct. 5-6**
Netherland Hilton Hotel, Cincinnati
New England Regional **Oct. 13-14**
M.I.T., Cambridge, Mass.
Michigan Regional **Oct. 19-20**
Michigan State University, East Lansing, Mich.
Purdue Regional **Oct. 26-27**
Purdue University, Lafayette, Ind.

New T&RI Course Deals With Casting Defects

Industry requests for an objective approach to the study of casting defects has led to the scheduling of "Scrap–Causes and Remedies." The course, No. 11, will be held Sept. 13-15 at the LaSalle Hotel, Chicago. The course fee is $60.

Two approaches will be made to the problem. One will be through lectures by industry authorities who will recommend possible approaches. The other will be through actual studies of defective ferrous and non-ferrous castings on each of the three days. Those attending the course have been requested to bring actual problem castings to the clinic.

A course was recently completed at Detroit on sand testing. Among the subjects discussed were base properties, molding sand properties, hot properties, core sand testing, and shell sand testing methods.

Emphasis was placed on correct laboratory procedures, sand properties, variables, and controls.

Four more courses will be presented during the last quarter. These are:

Metallurgy of Gray Iron, Oct. 2-4, Chicago, Fee, $60. The course deals with metallurgy of gray iron as applied to foundry production and castings application. Intended for metallurgists, engineers, foremen, supervisors, and management.

Sand Control and Technology, Oct. 16-18, Detroit, Fee, $60. Mold wall movement, hot deformation, creep deformation, mold atmosphere, heat transfer, mechanical properties, and metal penetration are studied. An instruction course for foundrymen who have had some experience in sand testing, control, and technology.

Cleaning Room Operation, Nov. 1-3, Chicago, Fee, $60. Practical instruction on all phases of cleaning room operation-layout, equipment, purchasing, materials, maintenance, ventilation, noise, safety, personnel, and production methods are included. Recommended for foremen, supervisors, engineers, and management.

Production Scheduling and Control, Dec. 4-6, Chicago, Fee, $60. Definitions and analyses of fundamental production problems are presented. Basic understanding and application of production criteria for effective and economical utilization of equipment, materials and manpower in the production of ferrous and non-ferrous castings. For industrial engineers, production control personnel, line supervisors, foremen, and managers.

Name Representatives for International

Three official delegates have been named to the 1962 International Congress to be held in May, 1962 in Detroit's Cobo Hall. They are AFS President A. L. Hunt, Vice-President J. A. Wagner, and General Manager Wm. W. Maloney.

Delegates have been named to the various committees of the International Committee of Foundry Associations. They are:

Committee on Testing Cast Iron—C. K. Donoho, American Cast Iron Pipe Co., Birmingham, Ala., and D. E. Krause, Gray Iron Research Institute, Columbus, Ohio.

Committee on Foundry Dictionary—A. L. Hunt, Superior, Foundry, Inc., Cleveland.

Committee on Foundry Properties of Materials—R. A. Clark, Union Carbide Metals Co., Div., Union Carbide Corp., Cleveland, and V. M. Rowell, Federal Foundry Supply Div., Archer-Daniels-Midland Co., Cleveland.

Working Group on Foundry Coke—C. F. Joseph, Miller & Co., Chicago, and W. W. Levi, consultant, Lynchburg, Va.

Working Group on Foundry Clays—J. B. Caine, consultant, Cincinnati, and R. W. Heine, University of Wisconsin.

Working Group on Testing CO_2 Materials—D. R. Chester, Archer-Daniels-Midland Co., Cleveland, and C. Phipps, University of Illinois.

Working Group on Malleable Iron—W. D. McMillan, Ohio Ferro Alloys Corp., Chicago, and Eric Welander, John Deere Malleable Works, Moline, Ill.

Working Group on Tendency Towards Hot Cracks—John A. Rassenfoss, American Steel Foundries, Chicago, and R. W. Heine.

AFS International Representatives—President A. L. Hunt and General Manager Wm. W. Maloney; European Representative Dr. A. B. Everest; and Australia Representative Wm. A. Gibson.

International Foundry Congress Acclaimed Success

Emphasis on New Technology Evident from Both Sides of Iron Curtain

Over 1000 metalcasters, representing 22 countries from both sides of the Iron Curtain met in Vienna, Austria, recently to exchange technical knowledge, opinions, and ideas.

Attending the 28th International Foundry Congress, the metalcasters heard eight of 29 papers delivered by foundrymen from behind the Iron Curtain. This fact helped make the meeting a "lifetime highlight" in the opinion of A. J. Kiesler, General Electric Co. Research Laboratory.

Kiesler, and Walter Seelbach, president of Superior Foundry Inc., Cleveland, were official U.S. delegates to the Congress. Kiesler was also the only American to deliver a paper, the official AFS Exchange paper (see MODERN CASTINGS, July, page 46).

Other Americans at the Congress included Chester F. Mally and C. Lane Mally, Stuart Foundry Co., Detroit; Paul J. Schneider, Wisconsin Centrifugal Foundry, Inc., Waukesha, Wis.; Carl and Joseph J. Tomasi, Denison Pattern Works, Inc., Cleveland; Klaus E. Leeb, Sivyer Steel Casting Co., Milwaukee; Charles E. Manning, G. E. Smith, Inc., Pittsburgh.

Discuss L-D Process

A technical highspot in the sessions came with the presentation of the Austrian paper "The 'L-D Process' for Steel Castings" by Rudolph Rinesch, United Austrian Iron and Steel Works.

This paper examined the advantages of applying the Linz-Donawitz (L-D) process of steelmaking to the production of steel castings. Rinesch described how the process (used both in Europe and to some degree in the United States) could be adapted to small scale foundry operations in the 5 to 30-ton range.

Discussion centered on this paper for some time, Kiesler reported, with the general consensus that this process would be suitable for foundries producing large steel castings if they have cupolas large enough to feed hot metal to the process.

Rinesch, who was speaking for his co-authors, H. Neudecker and J. Eibl, outlined the advantages of the basic-lined L-D crucible for the production of steel castings.

The process, it was reported, is suited for the production of alloyed steel castings as well, and a large number of castings have already been produced to show its applicability.

The point under discussion was that the L-D process could be put to work in smaller operations. If it is as practical as stated, it could, some said, bring down the price of castings.

Review Hot Tear Data

Another presentation of note was by Professor A. DeSy of the University of Ghent, Belgium. Professor DeSy and his associates reviewed data on hot tearing of steel castings to show a discordance in views and in some cases marked contradictions.

One conclusion drawn was that previous studies were attempted on sand-molded test bars, which made it impossible to keep all mold-depending factors constant.

The authors made use of a hot-tearing test bar cast in a metallic mold, obtaining a higher degree of constancy.

Explain Russian Process

B. V. Rabinovich, a Soviet representative, presented a description of the Russian "R" process for making thin-walled molds. This is a two-stage process. In the first stage a thin layer of sand is blown against the pattern, followed by a high pressure squeezing stage of backup sand. This is done in a shaped flask.

The results of the studies were used in developing the new process of molding the Soviet's "Volga" engine crankshafts.

The Russian claimed the process offers reduced consumption of molding materials, low costs of binding materials use, and an opportunity for high labor productivity.

A. M. Liass, also representing the USSR, presented a formal paper entitled "Some Problems of the Theory and Practice of the Use of Sodium Silicate Bonded Molding Sands by the Foundry Industry of the USSR."

This explains a successful application of molding sands combined with water glass for the production of castings weighing up to 80 tons.

There were other highly informative papers brought before the assembled foundrymen. Some of them are touched briefly here. If anyone wishes preprints, they can be obtained by writing to the Verein Osterreichischer Giessereifachleute, Vienna IX, Ferstelgasse 1, Austria.

Gas Holes in Castings Caused by Properties of Cores by J. Ornst–Czechoslovakia. A mathematical formula defining the conditions of gas hole formation in castings caused by the properties of cores has been derived. Gas content is expressed as a function of the core surface and not as a function of core weight.

Phosphorus-Embrittlement in Steel Castings and Possibilities of Its Elimination by J. Czikel–Germany. Brittleness of electric furnace and Bessemer steel castings increases with increasing content of sulphur and carbon. It is possible to tie up phosphorus as stable and insoluble phosphides by the addition of certain elements like calcium, cerium or magnesium.

Balance of Materials and Calorific Balance in Cold Blast Cupola by W. Patterson, H. Siepmann, H. Pacyna –Germany. The experimental results demonstrate that during the first hour the coke bed burns down considerably in order to compensate for the heat expended, but, generally, fills up again during the second hour by regular coke charges. Besides the correct adjustment of coke rate and blast volume, make sure that the increased coke requirements during the initial period of a melt are compensated by an appropriate height of the bed coke or by charging intermediate coke at the correct time.

"Study of Nuclei in Aluminum by the Granule Method" by C. Mascre, A. Touguet, M. Drouzy–France. The thermal analysis of calibrated granules enables the nuclei present in an alloy to be studied independently of the rate of growth of crystals. This separation of the two factors of grain size helps to assess clearly the part played by solidification nuclei.

Ultrasonic Detection of Defects in Cast Steel by A. H. Sully, J. D. Lavender–Great Britain. The paper describes an investigation of the effect of cast structure and rough surface on transmission of an ultrasonic beam and the sensitivity of defect detection.

Solidification of Eutectics by I. Minkoff—Israel. Refinement of the eutectic structure by rapid freezing is accompanied by a change of the growth form of silicon from plates to fern-like dendrites which are joined in a continuous network.

Directional Controlled Solidification of 100-Ton Steel Castings by P. Tavolotti, G. Iaccarino—Italy. Directional solidification principals have been applied to the casting of six rolling mill housings weighing 92 tons each. Casting has been carried out by using only one 22 ton riser for each housing. Yield has been 81 per cent.

Role of Calcium Production of S-G Iron by T. Kusakawa—Japan. Calcium is found to be moderately effective at elevated temperatures up to 1500° C, but is free from contribution to spheroiding in the freezing range. Although cerium has some similarities to calcium in physical and chemical properties, it has spheroidizing power even in the freezing temperature range.

Influence of Some Elements on Development of Eutectic Cells by C. Pelhan—Yugoslavia. Sulphur propagates the formation of nuclei by lowering the energy of boundaries. With the addition of titanium and aluminum, the crystal nuclei are removed from the liquid melt, melt tends to be undercooled, and graphite is finer.

Practical Experience in Melting of Black and White Malleable Cast Iron in the Guillamon Furnace by J. Guillamon, F. Lutz—Austria. A cupola furnace with super-heated bottom of the Guillamon system is described. Aside from an adjustable and extraordinarily precise control of the metal analysis, a high iron temperature can be obtained with purely synthetic charges.

Microscopic Methods for Study of Melting and Crystallization Processes by R. Mitsche, F. Gabler, W. Wurz, M. Brandstatter-Kuhnert—Austria. A metallurgical microscope of the inverted type is fitted with a micro-furnace. Easily viewed are the melting of the iron, the solution of the graphite spheres and, cooling down slowly, the reappearance of graphite and its growth.

New Characteristics for Determining Quality of Castings by A. Karamara—Poland. It was found that test pieces having similar magnetic properties have also certain similar mechanical characteristics. Since the new characteristics depend on the stress-strain diagram the magnetic test becomes a reliable method for non-destructive testing of castings.

Elastic and Mechanical Properties of Piston Rings by C. Englisch—Sweden. An investigation has been made on the elastic and mechanical properties of piston ring materials. The work is concluded by a summary of the elasticity and structural-stability values obtained for the various classes of material available in today's engine manufacturing.

The Application of Gas Blowing and Injection Processes by E. K. Modl—Switzerland. The first section deals with gas blowing treatments, especially the effects of nitrogen blowing in molten gray iron. The second section is devoted to foundry injection processes using reactive solids with inert carrier gases for carburizing, innoculating and modifying the graphite form in cast iron.

On the Flowability of Molding Sands by J. M. Navarro, J. Navarro-Alcacer—Spain. The amount of water in the mixture is the variable with the greatest influence. The mixture has a maximum penetration and retention-of-shape capacity for a certain water content which varies with the percentage of binder

The Effect of Slag on Properties of Cast Iron by F. Varga—Hungary. Changes in the slag composition causes at first an immediate change in the composition of the liquid iron —decrease of the slag basicity decreases the carbon saturation value. When slag volume increases carbon saturation value increases and mechanical properties fall off.

Other papers presented at the International Congress include: *Applications of Statistical Methods to Foundry Studies* by G. Blanc, J. C. Margerie—France; *Experiences with Low Pressure Die Casting in an Austrian Light Metal Foundry* by I. Berger—Austria *A Study of Factors Influencing Service Life of Slab Molds and Tests Aiming at Their Interpretation* by A. Cech—Austria; *Investigations of Longest Azdmissible Pouring Time of Steel Cast into Green Sand Molds* by K. Hess—Poland; *Investigation of Phenomena Occurring in Runners of Gating Systems of Iron Castings from the Point of View of Filling of Mold* by A. Kalman—Hungary; *Cast Steel with Special Magnetic Properties* by H. Luling, K. Gut—Switzerland.

Penn State Speakers Stress Quality as Key to Future

Warn foundrymen upswing in economy means increased competition, stricter requirements.

Encouraging signs of increased production provided an air of guarded optimism at the 3rd Biennial Penn State Foundry Conference held June 22-24 at University Park, Pa.

More than 200 foundrymen from the mid-Atlantic area attended. A MODERN CASTINGS check found a definite pickup of business in some areas, quite spotty in the big industrial centers, but a general feeling that the metalcasting industry is on the upturn. A common thought expressed was that the rate of increase predicted early in 1961 for the industry was too optimistic. Increased tonnage is expected but lagging behind forecasts made at the first of the year.

The theme running throughout the conference was that of quality, dependability, competition, and costs. Sessions stressed both new techniques and misapplied or neglected fundamentals. Whatever the subject covered, the basic theme was repeated. Controls were cited as the key to the foundrymen's operating problems and marketing as the solution to his sales troubles.

Need Strict Controls

Several speakers emphasized the importance of control factors. Said H. J. Heine, Malleable Founders' Society, "The key word in producing quality pearlitic malleable irons—or for that matter any quality product —is control." D. E. Krause, Gray Iron Research Institute, put it this way, "Successful iron quality control depends on using all available controls, not only one or two. There is no substitute for constant supervision of all features of the cupola operation."

W. H. Moore, Meehanite Metal Corp., stated that the increased competition from other means of fabrication could be a blessing in disguise. This, he stated, has forced foundries into producing materials with greater versatility and reliability. He emphasized that we must have basic theories to work with in controlling variations.

H. F. Scobie, Non-Ferrous Founders' Society, combined quality and marketing in this philosophy, "Contrary to what some of you may believe, customers in surveys are almost unanimous in placing quality first, service second, and price a poor third. Sell quality and service, don't use the 'I can-do-it-cheaper' approach. Don't give away your ingenuity and ability. Sell it and get paid properly for it."

Foundry subjects ranged from sand preparation through molding, melting and testing. Sessions were conducted in the general areas of gray and malleable iron, non-ferrous alloys, steel, and sand.

Gray and Malleable

Controls and control tests and their essential role in gray iron production were emphasized by D. E. Krause. Said he, "Although new control tests are being developed, many cupola operators get into trouble by not making adequate use of the relatively simple and inexpensive tests now available. The disreputable condition of some of the control tests in foundries is more responsible for apparent deficiencies of the test than the principles of the test."

Foundrymen are recognizing that sand changes in composition continually, and that constant moisture control is essential, said H. W. Dietert, Harry W. Dietert Co. He described a new sand system which controls the sand at a predetermined moldability level to achieve constant mold quality.

The moldability controller adjusts moisture to produce proper molding sand while the composition is changing under normal plant practices. Among factors controlling mold quality enumerated by Dietert are voids, creep, permeability, fracture, finish, lift and ramability.

Foundry attitudes are not keeping pace with technological developments, observed W. H. Moore, Meehanite Metals Corp., in commenting on the lag between development and application.

Said Moore, "Each foundry should have a definite process of charge selection and melting if it expects reproducible results. Too many foundries think that they can ignore some of these basic fundamentals and still make quality castings.

"This same reasoning and need for standardization of operating procedures can be applied throughout the sand preparation function, the molding operating, and the gating and risering of the castings. In all of these it is necessary to have a working theory to go by."

Flexibility and performance account for the spectacular rise in the use of pearlitic malleable iron, according to H. J. Heine, Malleable Founders' Society. "In today's sophisticated designs, emphasis is placed on increasing the strength to weight ratio. Pearlitic malleables offer the design engineer a wide range of properties from which to select," he remarked. Heine emphasized that strict controls must be enforced to secure the ultimate properties.

Non-destructive testing is a control mechanism for keeping manufacturing costs in bounds and meeting customer specifications, said Herman Guidici, American Chain & Cable Co. Proper use of testing will lead to better design, improved castings, and more efficient operations, he observed. Various standard non-destructive tests were enumerated and outlined by Guidici.

Three filmstrips, "What is Gray Iron," "The Properties of Gray Iron," and, "The Properties of Ductile and High Alloy Irons" were presented by Charles Walton, Gray Iron Founders' Society.

Non-Ferrous

"What's wrong with copper alloy castings?" asked H. F. Scobie, Non-Ferrous Founders' Society. "Nothing that we can't do something about—most of us can do better than we're doing today," he asserted. Scobie pointed out that copper alloy foundrymen must recapture markets and reverse the downward trend of the last 15 years.

Ways of improving physical properties of copper and aluminum alloys through grain refinement, degassing, and risering were explained by D. E. Wyman, Exomet, Inc. Porosity, he pointed out, was the major problem of aluminum. It can be controlled by vacuum degassing the molten metal by bubbling chlorine or nitrogen through the metal or by chemical additions. Wyman explained how insulating risers promote solidification and allow use of fewer and smaller risers. He pointed out that most of the heat loss from the riser is through the sand in non-ferrous metals.

The importance of control was advanced again by Jack Morgan, Foseco, Inc., in relating the effect of

treating molten metals by various chemicals with the results on quality and structure.

Morgan observed that precise treatment to be employed in any given case depends upon several factors including the type of melting unit, fuel, alloy being treated, form of the charge, and type of casting.

J. D. Allen and D. L. LaVelle, Federated Metals Div., American Smelting & Refining Co., as a team discussed melting, pouring, gating and risering, chills, vents, and defects in brass, bronze and aluminum. Simplified approaches to better brass and bronze castings were handled by Allen and aluminum castings by LaVelle.

Considerable interest was generated in a casting clinic conducted by the team. Sample castings were submitted by those attending for study. Possible causes for the defects and recommendations were made.

Steel

Continued increases in the use of furans was seen by R. J. Mulligan, Archer-Daniels-Midland Co. Three in particular were predicted—the shell molding technique, urea furan in combination with core oil, and straight furan for hot boxes. Essential to the process, said Mulligan, was strict control. Straight furan was recommended for steel castings, especially for large cores.

Common steel foundry problems can be resolved by pointing out irregularities in melting practices, chemical relationship of metal to slag, and temperature control, commented R. A. Frost, Vanadium Corp. of America.

Fundamental considerations which must be given to melting and ladle practice, pointed out by Frost are:

Refractory linings and their metal slag compatibility.

Slag and metal compatibility.

Changes in the above compatibilities as affected by temperature.

Changes in compatibility as affected by alloying.

Changes in these compatibilities as effected by degassifying.

Oxygen practices.

Compatibilities as they affect fluidity.

Use of a synthetic water-soluble polymer, used primarily for steel work at present, was explained by R. D. Green, Dow Chemical Co. Advantages claimed for the additive include improvement of green, dry, and hot sand properties and increasing mold production. It is used in amounts of 3/4 to 1 lb. per ton of sand with equivalent amounts of an additional powder.

Possible savings through the use of exothermics were advanced by Douglas Beath, Foseco, Inc. Exothermics properly applied, he pointed out, can lead to:

Increased yield.

Reduction in molding cost.

Reduction in riser cutoff and grinding.

Reduction in riser tonnage recirculating through the shop.

Reduction in cleaning room cost.

Frank Lees, Durez Plastics, Inc., discussed fundamentals of resin coated sand. He emphasized strength characteristics, effect of wax and accelerator, and gas volume.

Recent developments in magnetic particle inspection, were outlined by Kenneth Schroeder, Magnaflux Corp. Described was a new process which utilizes a high amperage DC source, pulsed in rapid sequence using black light and magnetic particles. The technique can be used on a production basis or equally well on extremely large castings.

Schroeder said that a 20-ton steel casting can be inspected in one hour. The operator can energize the system and spray at the same time.

The conference sand school was held on consecutive afternoons. Three-man panels were held at each school consisting of representatives from gray iron, steel, and non-ferrous foundries. Panelists described operations in their shop, followed by extensive question and answer periods.

George John, Foundry Div., Textile Machine Works, and James J. Silk, Taylor & Co., spoke on gray iron; Edwin J. Richard, Bethlehem Steel Co., and S. B. Donner, Donegal Steel Foundry Co., dealt with steel practices; and George D'Andrea, Danko-Arlington, Inc., and J. O. Ochsner, Crouse-Hinds Co., spoke on non-ferrous sand practices.

Two speakers also appeared on the sand program. E. G. Gentry, Humble Oil Co., spoke on carbon sand, and William Richards, Jr., discussed wetting agents in sand.

Gentry described the new non-silica molding medium as a "round-grain carbon sand." He stated that its principal claim to superior qualities are its low thermal expansion and inertness toward all metals except steel. Aluminum, bronze, and iron castings produced with carbon sand molds and cores are relatively free from defects associated with thermal properties of the molding medium. Castings show smooth surface finish and no veining, scabbing or burn-on, except under the most extreme conditions.

Richards observed that the use of excessive amounts of water causes more casting defects than any other single cause. Excessive moisture, he pointed out, is involved in 11 of the standard 14 casting defects. Richards described the mechanics of wet water, explaining how it promotes control through wetting, spreading wetting, and penetration. These actions evenly coat clay so that the clay is spread over the sand grains evenly and smoothly.

Committee in charge of the 3rd Biennial Penn State Regional Conference are, seated: Honorary Chairman Robert McCord, Pennsylvania State University; and Conference Chairman T. E. Eagan, Cooper-Bessemer Corp., Grove City, Pa. Standing: Treasurer H. P. Good, Textile Machine Works; Secretary W. P. Winter, Pennsylvania State University; and Vice-Chairman J. T. Gresh, American Brake Shoe Co.—by Walter Napp

Local Officers Get Inside View of AFS Operations

How services to AFS members can be improved were discussed by AFS staff personnel, national officers, and chapter chairmen at a two-day meeting.

Workshop sessions with members divided into four groups were held at the Central Office, Des Plaines, centering around AFS services. Meetings at the LaSalle Hotel were attended in a group.

AFS technical research activities were explained by AFS Technical Director S. C. Massari. The AFS Training & Research Institute and scope of the Society's educational program were evaluated by Education Director R. E. Betterley. Chapter functions including ideas for better administration and organization were handled by AFS President A. L. Hunt, General Manager Wm. W. Maloney, and Secretary A. B. Sinnett.

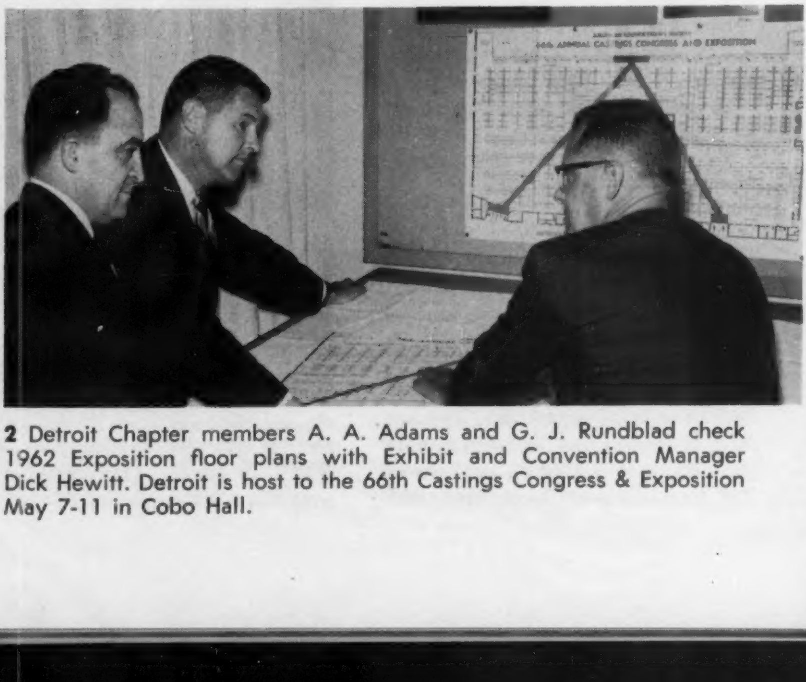
Modern Castings and its relation to the membership, industry, and advertisers was under the supervision of Managing Director H. E. Green and his staff. A "grass roots" survey of the chapter officers was taken covering market development, trends, buying, and Modern Castings. Highlights of the survey as well of the conference were carried in the July issue.

Meetings at the hotel dealt with regional administration meetings, planning of regional conferences, improving chapter programs, financing AFS activities, membership and dues, national nominations and elections, the 1962 International Foundry Congress, and what the Safety, Hygiene and Air Pollution control means to foundries.

How AFS activities were financed were explained by General Manager Maloney. This was followed by much discussion centered around the increase in membership dues (announced in June Modern Castings). Reasons for the increases and how the technical program will be strengthened were outlined.

A four-man panel of chapter officers explained how their local programs were improved. Participants were: J. L. Lowe, Saginaw Valley; K. H. Kostenbader, Philadelphia; L. S. Krueger, Wisconsin; and Bruce Farrow, Southern California.

1 AFS General Manager Wm. W. Maloney plays host to AFS President A. L. Hunt and Enrique Leon Andrade, Mexico Chapter, who enjoyed the outdoor luncheon at Society headquarters.



2 Detroit Chapter members A. A. Adams and G. J. Rundblad check 1962 Exposition floor plans with Exhibit and Convention Manager Dick Hewitt. Detroit is host to the 66th Castings Congress & Exposition May 7-11 in Cobo Hall.

3 MODERN CASTINGS Managing Director H. E. Green explains the purposes and functions of a business publication. Chapter Officers participation in a survey highlighted the fact that 86 per cent have a voice in the purchasing of foundry equipment. Over one-half the group foresees 1962 as a better year.

4 H. J. Weber, Director of Safety, Hygiene & Air Pollution, left, brings R. F. Hoffman, Metropolitan Chapter, up to date on recent air pollution legislation.

5 AFS Director of Education, R. E. Betterley, demonstrates apprentice contest patterns to J. W. Nielson, Utah Chapter, and M. P. Schroeder, Twin City.

6 Secretary A. B. Sinnett explains to Lawrence Winnings, Central Illinois, how galley proofs of chapter member names can be used to the best advantage in keeping each chapter at full strength.

7 General Manager Maloney, Technical Director Massari, President Hunt, and Vice-President Wagner, discuss tight schedule maintained during two-day meeting held at AFS Headquarters and in Chicago.

8 Texans Frank Page, W. W. Massey, and Jake Maenza examine AFS-produced technical publications containing the newest in metalcasting technology.

9 J. F. Pace, Northwestern Pennsylvania, National Director D. E. Best, and K. H. Kostenbader, Philadelphia compare notes on improving chapter programs.

CHAPTER NEWS

Modern Castings Staff Makes Foundry Tour

Allan Nolan, Gilbert Totten, Walter Christie, Charles Coffin, and Dwight Early, Jr., examine engine block castings.

Modern Castings sales personnel keep up with the latest metalcasting techniques in a tour of Howard Foundry Co., Chicago. Joe Lacerra, right, guided the group through the aluminum and investment casting departments. Examining an intricate casting are Gordon Early, Joseph Flanagan, and Art Larson.

Society Will Purchase Transactions Volumes

Requests by AFS members has reduced the Society's stock on many issues of TRANSACTIONS. In order to replenish its inventory, AFS will pay $5 for each TRANSACTIONS in good condition except for the following volumes: 54(1946), 63(1955), 65-(1957), 66 (1958), 67 (1959), and 68 (1960).

Members having books in good condition are asked to communicate with the AFS Book Department, Golf & Wolf Roads, Des Plaines, Ill., for authority to ship.

Wisconsin Chapter

Hot Box Binders

Hot boxes binders and their use were discussed by Wayne Buell, Aristo Corp., at one of the sectional meetings. He told gray foundrymen about sand mixes, curing times and temperatures, and necessary equipment.

The steel section heard a panel discussion on quality control. Programs used by foundries were reviewed and evaluated. Emphasis was placed on the characteristics of a sound control program.

Edward Stanko, Diamond Alkali Co., discussed CO_2 binders at the malleable meeting. He reviewed the effect of the SiO_2 to Na_2O ratio on properties developed by binders. Recommended mixing procedures were studied with the advantages of sodium silicate cores. Particular attention was paid to gassing time and the undesirable effects of under-and over-gassing.

Care and use of crucible and furnace refractories was explained to non-ferrous members by Crawford B. Murton, Vesuvius Crucible Co. He reviewed the fundamentals of good furnace practice including care, storage, and use of crucibles. Proper installation of crucibles and covers was also discussed. Emphasis was also given to proper charging techniques which prolong crucible life.

Martin C. Ehrman, Jr., International Harvester Co., gave a detailed review of the 1960-61 sectional programs to the pattern section. The importance of putting to practical use the many new ideas was emphasized. —by R. B. Ballmann

Tri-State Chapter

Safety and Human Relations

Safety must be emphasized daily by foremen to create and sustain an effective program, said E. J. Boywid, International Harvester Co., Memphis, Tenn. He pointed out that safety is not the job of top management but must be put on the workmen's level by the foreman.

By being more safety conscious, foundries today have reduced their accident frequency rates considerably. The speaker recommended first aid training for foremen, stating that many lives have been saved through on-the-spot treatment.

Past chairmen were presented with achievement certificates for the contributions to the chapter.—by Bobby Bell

NORTHEASTERN OHIO—Participating in Recognition Night were, standing, Norman Vicic, Artisan Pattern Engineering Co.; William Ackerman, Modern Pattern; Kenneth Kochule, Reliable Pattern; and Raymond Laudi, Aluminum Co. of America. Seated are David Domin, Artisan Pattern Engineering Co.; William Hoffman, principal, Max S. Hayes Trade School; John Matia, Cleveland Board of Education; and Thomas Buckingham, Ford Motor Co.

PHILADELPHIA—Cupola operations were explained by Robert Carpenter, Hanna Furnace Corp., second from left. Others are Chairman R. C. Stokes; Technical Chairman H. C. Winte, and Roger Keeley.—by Leo Houser and E. C. Klank

UTAH—Officers and Directors: Steven Beeley, Director; Jack Carter, 2nd Vice-Chairman; Fred Hafen, Treasurer; Everett Beckman, immediate Past Chairman; Byron MacKay, Chairman-elect; Warren Hunziker, Director; J. W. Nielsen, 1st Vice-Chairman.—by J. Merrill Bushnell

NORTHEASTERN OHIO—Winners in the chapter molding contest are Mel Bechemer and Eldon Felver, Grafton Foundry, and Jack Hall and William Gregory, Larson foundry.

Quad City Chapter

Scrap Processing Improvements

Technological improvements in the processing of ferrous scrap and charges in the areas of competition are certain to benefit foundries, said William S. Story, Institute of Scrap Iron & Steel, Washington, D.C.

He said that there are now methods for upgrading scrap—led by one technique which takes miscellaneous scrap—autos, refrigerators, stoves—and puts them through a cleaning and tearing process which produces small pieces of scrap having excellent melting characteristics.

Research is also being conducted to improve the chemical and metallurgical aspects of scrap and the effects of impregnating specially prepared bundles with carbon and other additives to develop new grades.

"As scrap struggles to compete with other raw materials, it seems to me that the foundries stand only to gain," stated Story. He predicted that scrap will be competitive with other metallics, and in the long run will have increased consumption.

Detroit Chapter

Aluminum Vs. Gray Iron

Current trends in iron and aluminum casting was discussed at a recent meeting. Dr. Robert F. Thomson, head, Metallurgical Engineering Dept., Research Laboratories, General Motors Corp., presented trends in aluminum. Harold N. Bogart, assistant director, manufacturing staff, Ford Motor Co., spoke for cast iron. Dr. Richard A. Flinn, Prof., Metallurgical Engineering, University of Michigan, served as moderator.

The discussion centered primarily on the automotive power plant. Such factors as the comparative engineering properties, comparative cost of the liquid metal on a density basis, plus manufacturing costs were discussed.

Although most of the technical problems of casting aluminum power plants have been solved, the question as to which casting method to use for high production appears to remain open. The pros and cons of gravity casting in semi-permanent and permanent molds, die casting and low pressure casting were mentioned.—by J. H. Barron, Jr.

Oregon Chapter

Holds Casting Panel

Castings problems were diagnosed at a recent meeting by a panel of Portland foundrymen. Those participating were Phil Laugen, Oregon Steel Foundry; Tom Sneddon, Columbia Steel Castings Co.; Darwin Wissenback, Crawford & Doherty; J. Goelher, Central Brass; and Carl Mattson, Dependable Pattern Works. W. A. Meyer, Esco Corp., served as moderator.

Following the business meeting, members toured the plant of Columbia Machine Works, Vancouver, Wash.—by Bill Walkins

TEXAS—Chapter Chairman W. W. Massey, consultant, elected at annual business meeting.—by C. Eugene Silver

Twin City Chapter

A Look into the Future

Half of the students now in school will step into jobs that don't exist at the present time, H. P. Pluimer, science consultant, Minnesota Dept. of Education, told foundrymen.

In a departure from a technical talk, the speaker outlined the expanding fields of technology. Typical of this is the chemical industry, said the speaker. Using the 10-year chemical abstracts as a yardstick, the speaker found that the 1905-1915 publication was contained in a 1000-page volume. From 1915-1925 the book grew to slightly over one volume. From 1925-1935 the data was contained in five volumes of 1000 pages each. From 1935-1945, nine volumes of 1000 pages each were required. From 1945-1955 the data was contained in 18 volumes of 1500 pages each. It is estimated that during 1955-1965, a total of 80 volumes of 1500 pages each will be required. —by Matt Granlund

Connecticut Chapter

Cutting Foundry Costs

How foundries can cut costs through controls was explained by Roger B. Sinclair, Roger B. Sinclair Associates. He emphasized the need for budgets and budget controls and outlined the use of break-even charts in establishing realistic costing and pricing procedures.

Officers were elected for the 1961-62 year. They are:

Chairman, Stafford W. Chappell, Electric Boat Div., General Dynamics Corp.; Vice-Chairman, Harry C. Ahl, Malleable Iron Fittings Co.; Secretary, George H. Caligan, American Refractories & Crucible Corp.; Treasurer, Frank B. Diana, Frank B. Diana Co.—by W. J. Sommer

San Antonio Section

Care of Pattern Equipment

Selection and use of wood for patternmaking was explained at the final meeting by Frank Page, Alamo Iron Works. His discussion included data on various pines and hardwood, seasoning, kiln drying, effects of air and shop conditions, shrinkage and checking, and moisture controlled storage of lumber.

A film was also shown on the story of stainless steel.

Page was elected as chairman for the coming year. Harold Fraunhofer, Kincaid-Osburn Steel Castings, Inc., was named as co-chairman. Ralph Thompson, Kincaid-Osburn Steel Castings, Inc., was elected secretary and treasurer.

NORTHWESTERN PENNSYLVANIA—Human relations as applied to the foundry industry was explained by Les Giblin. On right is Educational Chairman W. J. Wilmot, Urick Foundry Co.—by Walter Napp

EASTERN CANADA—Incoming Chairman W. Tibbits receives congratulations from outgoing Chairman L. Myrand.—by J. C. Cherrett

PITTSBURGH—A recent speaker was Roy C. Randles, Jas. H. Matthews & Co., left, shown with Technical Chairman C. E. Decker, Acheson Mfg. Co.—by Walter Napp

TWIN CITY—Technical Chairman Frank Ryan prepares to introduce speaker Jeff Westover who outlined reliable cost methods.—by Matt Granlund

WISCONSIN—First place winners in chapter competition were: metal patternmaking, N. Krueger, Allis Chalmers Mfg. Co.; wood patternmaking, G. Place, Wisconsin Aluminum Foundry Co.; non-ferrous molding, F. Hansen, Eck Foundry; and ferrous molding, D. Pickering, Zenith Foundry Co.—by Bob DeBroux

PITTSBURGH—Speaker J. M. Stana, Warner & Swasey Co., Cleveland, flanked by Prof. A. B. Draper, Pennsylvania State University, and Education Chairman J. O. Denny, J. S. McCormick Co.—by Walter Napp

PITTSBURGH—Attending a recent chapter meeting were 12 students of Pennsylvania State University who are taking foundry engineering courses.—by Walter Napp

METROPOLITAN—Technical Chairman J. J. Silk, Taylor & Co., left, shown with speaker C. H. Wenninger, Beardsley & Piper Div., Pettibone-Mulliken Corp.—by Walter Napp

ONTARIO—Speaker C. J. McFayden, Canadian General Electric Co., left, and technical chairman H. J. Hugh, Eureka Foundry & Mfg. Co. —by E. J. Skelly

METROPOLITAN—Official greeters are C. E. Langan and J. C. Hughes, Federated Metals Div., American Smelting & Refining Co.—by Walter Napp

UTAH—Outgoing Chairman Everett Backman, right, hands gavel to incoming Chairman Byron R. MacKay.—by J. Merrill Bushnell

OREGON—A. A. Belusko, Esco Corp., left, receives congratulations as retiring chapter chairman from immediate past president Carl Mattson, Dependable Pattern Works. Belusko received merchandise certificates and luggage. Morgan Rudich, Oregon Steel Foundry, is the new chairman.—by Bill Walkins

TENNESSEE—Outgoing Chairman Thomas A. Deakins, left, receives chapter gifts from incoming Chairman James L. Payne.—by J. D. Kling

Piedmont Chapter

Water-Cooled Cupolas

Advantages of the water-cooled cupola, including longer operation and higher tapping temperatures were outlined by H. W. Schwengel, Modern Equipment Co., Port Washington, Wis.

He tracted the evolution of the convention cupola to the present type incorporating hot blast, water-cooled protruding tuyeres, sloping tuyeres, carbon wells, elimination of linings, and water-cooled shells.

Plant visitations were made to Richard Foundry Corp. and the Norfolk, Va., Ford Motor Co. assembly plant.—by Larson E. Wile

PIEDMONT—Speaker H. W. Schwengel, second from left, with Chapter Officers Stephen Richard, Rickford Hanner, and Regional Vice-President D. E. Matthieu.—by Larson E. Wile

Future Meetings and Exhibits

Aug. 28-Sept. 1 . . American Society of Mechanical Engineers, International Heat Transfer Conference, University of Colorado Campus, Boulder, Colorado.

Sept. 17-21 . . Non-Ferrous Founders' Society, Annual Meeting, Shawnee Inn, Shawnee on Delaware, Pa.

Sept. 21-22 . . Missouri Valley Regional Conference, Rolla School of Mines, Rolla, Missouri.

Sept. 22-23 . . East Coast Regional Foundry Conference, Statler-Hilton Hotel, New York.

Sept. 24-26 . . Steel Founders' Society of America, Fall Meeting. The Homestead, Hot Springs, Va.

Oct. 5-6 . . Ohio Regional Conference. Netherland Hilton Hotel, Cincinnati.

Oct. 13-14 . . New England Foundry Conference, Massachusetts Institute of Technology, Cambridge, Mass.

Oct. 16-21 . . National Industrial Sand Association, Semi-Annual Meeting. The Greenbrier, White Sulphur Springs, W. Va.

Oct. 19-20 . . Michigan Regional Foundry Conference. Michigan State University, East Lansing, Mich.

Oct. 23-27 . . American Society for Metals, Detroit Metal Show (43rd Nattional Metal Congress and Exposition), Cobo Hall, Detroit, Mich.

Oct. 26-27 . . Purdue Metals Castings Conference, Purdue University, Lafayette, Ind.

Nov. 13-15 . . Steel Founders' Society of America, Technical & Operating Conference. Pick Carter Hotel, Cleveland.

Nov. 15-17 . . National Foundry Association, Annual Meeting. Savoy-Hilton Hotel, New York.

May 7-11, 1962 . . AFS 66th Annual Castings Congress and Exposition, In conjunction with The 29th International Foundry Congress . . Cobo Hall . . Detroit.

AFS Chapter Meetings

Canton District . . Aug. 5 . . *Annual Picnic & Golf Outing,* Brookside Country Club, Barberton, Ohio.

Chicago . . Aug. 19 . . *Annual Outing and Golf Tournament,* Nordica Hills Country Club, Itasca, Ill.

St. Louis . . Aug. 9 . . *Picnic,* Shady Acres Grove, St. Louis, Mo.

Twin City . . Aug. 14 . . *Summer Golf Party,* Midland Hills Country Club, St. Paul, Minn.

Foundry Trade News

Superior Steel & Malleable Castings Co. . . . Benton Harbor, Mich., will cease operations of its malleable division on Sept. 1. The company states that malleable operations are being discontinued "due to a cost-price squeeze and to the constantly diminishing requirements for the production of jobbing malleable." Engineering, technical, and sales staffs will be retained and efforts directed to production of steel castings by conventional as well as shell molding processes. During the past year, approximately 3/4 of a million dollars has been spent on the steel foundry.

National Bureau of Standards . . . has broken ground for a 20-building, $104 million research facility at Gaithersburg, Md.

American Brake Shoe Co. . . . announces that its cast iron freight car wheel plant at St. Louis, is being converted to the manufacture of "Southern" cast steel wheels at a cost of $2 million. The company is also spending $1 million to expand a large, modern cast steel wheel plant at Calera, Ala. American Brake Shoe also operates cast iron wheel plants at Toledo, Ohio, and Portsmouth, Va.

Ralph DuBois Foundry . . . Tulsa, Okla., has moved into a Normandy style building, housing the foundry, showroom, and office. The foundry manufactures exclusive ornamental hardware, casting from its 9000 patterns or any design designated by discriminating customers. Pouring is done in specially treated molds. Patterns are molded in clay, plaster or natural material such as sea shells. DuBois started his business after discharge from the Navy 15 years ago, starting in a little shop building owned by his father.

National Castings Co. . . . is the new name for National Malleable & Steel Castings Co., Cleveland. The company, founded in 1868, is one of the country's leading independent foundries, with five divisions and three wholly-owned subsidiaries in the U. S. and Canada. Twelve plants are operated. Originally the company manufactured cast iron lightning rods, rakes, hooks, and fencing. In 1891 the first major growth step was taken as Cleveland Malleable Iron Co. joined with foundries in Chicago, Indianapolis, and Toledo, Ohio, to form National Malleable Castings Co. In 1923 the company's name was changed again, reflecting the increasing importance of steel castings.

Detroit Gray Iron & Steel Foundries Co. . . . has moved into a new 8000 square foot building in Oak Park, Mich. It has four induction furnaces with capacities ranging from 100 to 2500 lb capacity and will specialize in Shaw process castings of dies.

G. E. Smith, Inc. . . . Pittsburgh, Pa., has signed a license agreement with Gebr. Huttens KG, Dusseldorf, which will result in its no-bake binder and a new binder for the hot box process being manufactured in Germany. G. E. Smith has also created a new Industrial Div. to manufacture and distribute a line of products which supplements the firm's binders and other chemicals for the foundry industry. The division's first product is a new waterless hand cleaner. The company has moved its general offices to 50 per cent larger quarters at 4 W. Manilla Ave., Green Tree, Pa.

Casting Equipment, Inc., . . . Berea, Ohio, has been appointed sales representative in Ohio for Detroit Electric Furnace Div., Kuhlman Electric Co., Birmingham, Mich.

Foundry? Yes, its the Ralph DuBois office, showroom, and foundry, Tulsa, Okla., manufacturer of custom ornamental hardware. Company has 9000 patterns on hand, pours about five tons of yellow brass a year.

Woodward Iron Co. . . . Woodward, Ala., and directors of Lynchburg Foundry Co., Lynchburg, Va., have agreed, tentatively, on a basis by which Woodward Iron will acquire substantially all of the net assets of Lynchburg Foundry in exchange for Woodward common stock. The announcement was made in a joint statement. Following formal ratification by the respective boards of directors, stockholder action to the extent necessary will be solicited. Consummation of the transaction will provide Woodward Iron Co. with a new market and outlet for its merchant iron and reportedly strengthen the operations and services of both companies. In its expansion program, Woodward acquired Alabama Pipe Co., Anniston, Ala., in 1959; Western Foundry Co., Tyler, Texas, also in 1959; and Anniston Foundry Co., Anniston, Ala., in 1961. In 1955 Woodward expanded its holding by purchase of Longview Line Corp., Sanginaw, Ala.

Malleable Founders Society . . . members were challenged to "push out the boundries of their existing markets" by incoming president Robert S. Bradshaw at the group's annual meeting. Bradshaw, president and general manager, Texas Foundries, Lufkin, Texas., succeeded Charles P. Speitel, Pennsylvania Malleable Iron Co., Lancaster, Pa., as president. Joseph B. Gutenkunst, Milwaukee Malleable & Grey Iron Works, Milwaukee, was named as director and vice-president. Elliot F. Metcalf, vice-president, Westmoreland Malleable Iron Co., Westmoreland, N. Y., and L. Edward Roby, Peoria Malleable Castings Co., Peoria, Ill., were named as directors.

Harvey E. Steinhoff, Wagner Castings Co., Decatur, Ill., was given the McCrea Medal, awarded annually for significant contributions to the industry. Steinhoff was cited for his years of service.

Alloy Casting Institute . . . re-elected J. D. Hagans, Ohio Steel Foundry Co., Springfield, Ohio, as president, at its 21st annual meeting. Others elected are: vice-president, J. W. MacKay, American Cast Iron Pipe Co., Birmingham, Ala., executive vice-president, and treasurer, E. A. Schoefer; directors, W. D. Raddatz, Electro-Alloys Div., American Brake Shoe Co., Elyria, Ohio, and T. R. Heyward, III, Duraloy Co., Scottsdale, Pa.

Central Foundry Co. . . . New York, has formed a new corporation which plans to build a 1000-home community in the Washington, D. C., area.

Ductile Iron Section . . . Gray Iron Founders' Society, conducted its first annual meeting at Case Institute of Technology, Cleveland. Included on the program were: "Heat Treatment of Ductile Iron," Dr. Lynn Ebert, Case Institute; a panel discussion on "Treatment and Analysis Vs. Final Properties;" "Review of Current Ductile Iron Gating and Risering," Prof. J. F. Wallace, Case Institute; "Casting Design Consideration," Prof. D. K. Wright, Case Institute; "Report on Survey of G.I.F.S. Ductile Producing Members," Richard Meloy, G.I.F.S. Marketing Director.

Members of the panel were: moderator, C. F. Walton, G.I.F.S.; David Matter, Ohio Ferro-Alloys Corp.; R. A. Clark, Electro-Metallurgical Co., Div. Union Carbide Corp.; H. H. Wilder, Vanadium Corp. of America; and R. E. Savage, International Nickel Co.

"Compositional Effects on Heat Treated Properties of Ductile Iron," J. F. Wallace and L. J. Ebert, is a report of original work sponsored by G.I.F.S. The investigation discloses that silicon is effective in increasing the critical temperature range and in raising the tempering response. Manganese, in amounts up to 1.10 per cent, decreases the critical temperatures, improves hardenability, and reduces tempering response.

Koppers Co., . . . Pittsburgh, Pa., will dedicate its new research center late this month. It is located on a 176-acre tract just east of Monroeville, Pa., near Pittsburgh. Estimated costs for land, construction, and equipment run between $8 and $9 million.

AFS . . . has been awarded a certificate in recognition of its charter membership in the American Society for Testing Materials. Ten other companies and institutions were cited for 60-year membership at the A.S.T.M. 64th annual meeting.

Let's Get Personal . . .

John Pohlman . . . has been named president of Pohlman Foundry Co., Buffalo, N. Y. Others elected: **Dan Pohlman,** vice-president of sales; **William Pohlman,** vice-president of operations; and **Emil Piper,** general manager.

Max Reading . . . has been elected to the board of directors, Foundry Services (Canada), Ltd., Guelph, Ontario. Reading is a past chairman of the AFS Eastern Canada Chapter. He will continue to administer the company's technical service and sales operations from his Montreal divisional headquarters.

Robert E. Levitan . . . appointed to newly created position of manager, marketing services, for Vitro Chemical Co. Div., Vitro Corp. of America, New York.

R. G. Parks . . . elected a vice-president of National Castings Co., Cleveland, and will remain as treasurer. **Robert C. Lewis** has been promoted to controller. The post was made vacant by the appointment of **Roy Willison** who became vice-president and general manager of the company's Industrial Div.

L. P. Pedicini . . . Lester B. Knight & Associates, has returned from Zurich, Switzerland, where he modernized foundries in 11 countries.

William H. Baer . . . Materials Branch, U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va., has been awarded certificate and a cash award of $250 in recognition of his work in the Metallurgy and Materials Conservation Section of the Materials Branch.

Roy Willison . . . promoted to vice-president and general manager, Industrial Div. National Castings Co., succeeding **Roy C. Hobson.** The Industrial Div. has plants in Cleveland, Chicago, and Indianapolis.

Jerry Leary . . . elected executive vice-president, Cincinnati Steel Castings Co., Cincinnati. **Robert S. Ragan** named as vice-president and director.

Otis J. Adams . . . named chief engineer, Bartlett-Snow Div., Bartlett-Snow-Pacific, newly formed by the purchase of C. O. Bartlett & Snow Co. by Pacific Foundry & Metallurgy Co. Adams will headquarter in Cleveland. **James W. Hill** has been named plant manager and will also headquarter at the Cleveland plant.

Arthur H. Pencek . . . secretary-treasurer and foundry superintendent, Crescent Aluminum Castings Co., Chicago, has been named father of the year by the Chicago Area Father's Day Council. Edward A. Pencek, a brother and vice-president of Crescent Aluminum, was one of the 37 finalist runners-up. Neither was aware that the other had been entered in competition.

Warren A. Logelin . . . is director of public relations and advertising for American Steel Foundries, Chicago.

Thomas A. Claiborne . . . named as general sales manager, Alloy & Metals Div., Tennessee Products & Chemical Corp., Nashville, Tenn. District sales offices are at Detroit, Chicago, Pittsburgh, Pa., Houston, and St. Louis. **James C. Hollway** named as manager of the Detroit sales office.

George J. Peer . . . named as general sales manager, Basic, Inc., Cleveland. He was formerly sales engineer, Chicago district sales manager and sales manager for the company's furnace products division.

John D. Pizzini . . . appointed technical sales representative for Foseco, Inc., Cleveland. He will represent Foseco in eastern Maryland, Delaware, District of Columbia, southern New Jersey, and eastern Pennsylvania.

David M. Gibson . . . is manager of marketing services, Hitchiner Mfg. Co., Inc., Milford, N. H.

George Bradshaw . . . retired as a master molder, U. S. Navy Yard, Philadelphia, after more than 40 years in the foundry industry. He recently celebrated his 70th birthday. He is an active member of the AFS Philadelphia Chapter and has served as chairman and director.

Stuart D. Walker . . . appointed district manager of a new sales office for Hevi-Duty Electric Co., Watertown, Wis. The office in the Boston area is in Dedham, Mass.

Frank H. Edgar . . . appointed division vice-president of aluminum sales, Olin Mathieson Chemical Corp., succeeding **Derek Richardson,** named vice-president of marketing, Chemical Div. **Edward B. Reynolds** is now assistant director of aluminum field sales and **Charles I. Vogel** named as manager of the newly established eastern sales region which includes the Boston, New York, Philadelphia, and Atlanta sales district.

R. E. Wells . . . named president, Chicago Foundry Co., Chicago, succeeding **R. I. Wells** who remains chairman of the board. **Charles E. Fausel,** formerly plant superintendent is vice-president in charge of operations. **Thomas W. Scanlan** is now treasurer.

F. Kenneth Iverson . . . is executive vice-president, Coast Metals, Inc., Little Ferry, N. J. He was previously sales manager of Cannon-Muskegon Corp.

Phil Sommerlad . . . named as greater Cleveland sales director for Lester Castings, Inc., Bedford, Ohio. He will retain his interest in Specified Maintenance Products, a Cleveland sales agency.

Joseph F. Knight . . . is now vice-president of operations for Kaiser Refractories Div., Kaiser Aluminum & Chemical Corp. He is responsible for operations of the division's nine domestic plants.

Kenneth S. Cowlin . . . appointed to newly created position of general sales manager, Electro Refractories & Abrasives Corp., Buffalo, N. Y. **Ernest H. Faust, Jr.,** has joined the research staff.

John W. Goth . . . named manager of foundry sales for Climax Molybdenum Co., Div. American Metal Climax, Inc. He will headquarter in Chicago. Foundry sales offices are also maintained in Dayton, Ohio, and New York.

Circle No. 148, Pages 133-134

New Products and Processes

What's new in foundry methods and equipment? Summaries are presented below. Circle corresponding number on free postcard, page 133. Mail it to us; we'll do the rest.

Vacuum Degassing Unit Eliminates Impurities in 5 to 10 Minutes

Vacuum degassing unit especially suited for foundry operations, provides a simple means for removing trapped gases from molten metal. The "package unit" consists of cylindrical vacuum chamber with quick-closing and quick-opening cover that swings horizontally on a pivoting jib-crane, and a pumping system capable of evacuating the chamber to the desired vacuum.

The elements are mounted on a common base-plate occupying less than 20 square feet of floor space. Most of the trapped oxygen, nitrogen, and hydrogen have been pumped out of the melt, as well as some dissolved gases, in five to 10 minutes. In addition, the rapid churning action produced by the vacuum flushes the dross to the surface, minimizing entrainment. F. J. Stokes Corp.

Circle No. 1, Pages 133-134

Universal Grinder-Polisher Unit Virtually Eliminates Vibration

Universal polisher-grinder virtually eliminates vibration and rollout. Compact low silhouette reduces operator fatigue. The pan, lap, polishing wheel, and cover can be changed as one unit in seconds without danger of contamination. Geoscience Instruments Corp.

Circle No. 2, Pages 133-134

Three New Core Mold Washes Provide Improved Suspension

Three new alcohol washes, tailor-made for all core and mold applications reportedly offer better suspension and require no special solvents. One, a combination of refractory minerals and graphite is used for coatings except those requiring a carbon-free coating. In these cases the second wash is substituted. The third, highly heat-resistant, is a rich graphite coating applied where more accurate surface finish is desired.

Tests show improved sand peel and finish saving time and labor in drying, corrects many "burn in defects", will remix easily, and flatten out rapidly. Frederic B. Stevens, Inc.

Circle No. 3, Pages 133-134

Perforated Vents for Shell Mold, Hot Box, Resist Loosening

Vents for use in shell mold and hot core box work resist loosening through repeated changes from room ambient to temperatures of 500 F. The perforated saucer-shaped disk is filled with holes about 0.010 in. in diameter. Three simple steps complete installation. Martin Engineering.

Circle No. 4, Pages 133-134

Waterless Hand Cleaner Removes Binder Stains and Other Dirt

Waterless hand cleaner removes stain of certain types of binders from coremakers' hands as well as all types of soil including grease, paint, carbon, ink, tar, aspalt, etc. Water can be used without cutting effectiveness. Industrial Div., G. E. Smith, Inc.

Circle No. 5, Pages 133-134

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AUGUST 1961—1

Valid through Oct. 1961

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12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216

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For The Asking

Build an idea file for improvement and profit. Circle numbers on literature request card, page 133, for manufacturers' publications.

Materials handling equipment . . . 20 pages, covers complete line of fork trucks, powered hand trucks, straddle carriers, towing tractors, attachments, and container handling equipment. Brochure is divided by product lines into 12 sections. Industrial Truck Div., Clark Equipment Co.

Circle No. 25, Pages 133-134

Alloy characteristics and capabilities . . . of self-aging aluminum-zinc prime alloy are contained on brochure. Also suggested foundry practices for alloy said to produce higher mechanical properties, better surface finish, and machining characteristics. Kaiser Aluminum & Chemical Sales, Inc.

Circle No. 26, Pages 133-134

Plywood pallet specifications . . . for Douglas fir and western softwoods create two vertical, well defined grades for pallets and containers. Specifications cover types, grades designs, styles, and construction techniques; nomenclature and definitions; materials and species of lumber; permissible lumber characteristics, methods and fastenings and their applications; fabrication particulars; permissible nailing defects; and dimensional tolerances. National Wooden Pallet M'frs. Association.

Circle No. 27, Pages 133-134

Batch-type airless abrasive blast . . . cleaning machines catalog describes the complete line. Six sizes of this machine, ranging in operating loads capacity from seven cubic feet to 100 cubic feet, are described. Also includes an analysis of cleaning costs. Wheelabrator Corp.

Circle No. 28, Pages 133-134

Physical testing machines . . . catalog lists more than 1200 machines for all industries. Equipment compiled from world wide sources including units made by company. Testing Machines, Inc.

Circle No. 29, Pages 133-134

Multi-use fabricating machine . . . may be used in foundries for prolonging flask life by straightening sand joints, replacing worn bushings and pins, and correcting corner angles. Warped core plates and bent flasks are said to be easily straightened. Four standard sizes. Dace Industries.

Circle No. 30, Pages 133-134

Aluminum casting alloy . . . eight-page bulletin outlines alloy developed for use where higher yield strength and lower elongation are required. As-cast and aged at room temperature, it developes a high combination of physical and mechanical properties with high yield strengths. William F. Jobbins, Inc.

Circle No. 31, Pages 133-134

Time zone . . . and daylight-saving time differences are indicated on U. S. map. Handy for long distance phone users and travelers. U. S. Industrial Chemicals Co.

Circle No. 32, Pages 133-134

Covering and refining fluxes . . . leaflet describes properties for use in melting copper-and-nickel alloy scrap. Contains instructions for use in crucibles, reverbatory, and rotary furnaces and lists grades for various applications. Foseco, Inc.

Circle No. 33, Pages 133-134

Air compressor catalog . . . 16 pages, includes complete line, more than 200 models of gasoline and electric driven—featuring automatic start-and-

Circle No. 151, Pages 133-134

stop and constant running units, plus illustrations and descriptions of compressors available with either horizontal or vertical tanks. Lincoln Engineering Co.
Circle No. 34, Pages 133-134

Steel resistance to hydrogen . . . at high temperatures, translation of Germany article, includes considerable data on many German steels previously virtually unknown in the U. S. Climax Molybdenum Co., Div. American Metal Climax, Inc.
Circle No. 35, Pages 133-134

Metal marking pressures . . . serve as guide to determine the approximate pressures to correctly mark metals. Charts aids in eliminating pretesting. Steel Marking Tool Institute.
Circle No. 36, Pages 133-134

Molds ovens . . . using high velocity heated air directly and directionally by patented air distribution system is explained in eight-page bulletin. Foundry Equipment Co.
Circle No. 37, Pages 133-134

Industrial glove . . . catalog lists applications and includes performance chart for easier selection. B.F. Goodrich Industrial Products Co.
Circle No. 38, Pages 133-134

Cut foundry inefficiency . . . through on-the-job operational and engineering assistance is theme of four-page booklet on metalcasting functions. Brown Metals, Inc.
Circle No. 39, Pages 133-134

Cast iron properties . . . of 40 irons and alloys are outlined in readable chart form in six-page booklet. Photos illustrate typical castings. Hamilton Foundry, Inc.
Circle No. 40, Pages 133-134

Scientific instruments . . . apparatus, and equipment are covered in 200-page book. Classified by groupings. Contains over 450 items. Labline, Inc.
Circle No. 41, Pages 133-134

Initial bubble test . . . for determination of hydrogen content in molten aluminum, A MODERN CASTING's reprint, describes instrument and method. American Foundrymen's Society.
Circle No. 42, Pages 133-134

A.S.T.M. publications . . . 62 pages, covers more than 300 items, 40 of which are new and not previously listed. American Society for Testing Materials.
Circle No. 43, Pages 133-134

Tooling plastics . . . in the foundry, eight-page brochure, illustrates applications with details for use. Advantages listed include lighter weight, longer wear, cleaner and more accurate draws, speed, and economy. Furane Plastics, Inc.
Circle No. 44, Pages 133-134

Grinding stresses . . . cause, effect, and control, 81 pages, comprises collected papers published in trade press. Compiled information proves good grinding is not detrimental to fatigue strength. Grinding Wheel Institute.
Circle No. 45, Pages 133-134

Polymers for core oil . . . booklet relates how cores of greater strength and uniformity are produced at faster baking speeds. Velsicol Chemical Corp.
Circle No. 46, Pages 133-134

Mechanical Training Courses . . . an 11-page brochure describing in detail the intensive technical courses offered by the AFS-Training and Research Institute. Includes registration form, tuition fees and details as well as location of all T&RI courses being offered in 1961.
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Classified Advertising

For Sale, Help Wanted, Personals, Engineering Service, etc., set solid . . 35c per word, 30 words minimum, prepaid. **Positions Wanted** . . 10c per word, 30 words minimum, prepaid. Box number, care of **Modern Castings,** counts as 10 words. **Display Classified** . . Based on per-column width, per inch . . 1-time, $22.00 6-time, $20.00 per insertion; 12-time, $18.00 per insertion; prepaid.

HELP WANTED

SALES MANAGER
Excellent opportunity for person experienced in sales management of custom castings, forgings, or machined components through manufacturers representatives to customers in heavy industry. Must assume full responsibility for sales management including market analysis, advertising, promotion, sales adminstration, and management of the field sales force for long-established firm with about $5 Million annual sales. Mechanical engineering background desirable but not as important as comprehensive industrial marketing abilities. Salary and incentive. **Please send resume to Box H-106 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRY SUPERINTENDENT for a Green Sand Electric Steel and Iron Foundry. This is a foreign assignment for a three-year engagement. Living conditions are good. Salary $18,000 per year; first class air transportation paid to and from country of employment, with three months full salary paid at end of contract and two weeks local leave annually. Superintendent must be a competent Steel Metallurgist and thoroughly experienced in sand molding practice and the operation of an Electric Steel Foundry. In reply, please submit typed application and resume in duplicate giving full outline of past experience, age, whether married or single. Include recent photo. **Overseas Industrial Services, 681 Market Street, San Francisco 5, California.**

MAINTENANCE FOREMAN
ELECTRICAL
Leading steel foundry in the East will have position available for a man thoroughly qualified to handle a variety of problems in electrical maintenance and new installations. All candidates must have well diversified experience ranging from electronics to high tension work and be fully acquainted with modern maintenance management techniques. He must be able to get maximum productivity from his people. For all this the man of our choice will be paid well, have good employee benefits with lots of challenge and opportunity for the future. **Complete resumes should be addressed to Box H-103 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

SALES ENGINEER
A challenge in selling quality castings for established Mid-West foundry. Knowledge of aluminum foundry operations metallurgy, and casting design essential. **Reply to: Box H-105 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

COREROOM FOREMAN — Progressive mid-west malleable jobbing foundry needs foreman with experience in an incentive shop. Must have a background of working out production problems with oil sand as well as shell and CO_2. Age 30-45. **Send complete resume to Box H-101 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

SALES MANAGER
Leading Mid-West manufacturer seeking manager to supervise sales of Corebinder. Position requires knowledge of modern foundry practice plus ability to sell and to supervise activities of other salesmen. **Submit resume, giving full details of background and experience, to Box H-104 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

INVESTMENT CASTING
Rapidly growing precision casting firm offers these challenging opportunities for young men with imagination and drive.

CHIEF ENGINEER
Will have complete responsibility for the development of all new production jobs, including tooling, gating, sample runs, etc. Will also be responsible for metallurgical work in Casting and Heat Treating Departments. Degree in metallurgy and foundry gating experience necessary for qualification. Work is related to ferrous, nickel, and cobalt base alloys, both air and vacuum melt.

PRODUCTION SUPERINTENDENT
This position, reporting to the Production Manager, involves the supervision of all production departments. Several years of successful experience in direct production supervision required. Steel foundry experience, and particularly investment casting experience, desired.
Excellent working conditions—profit sharing—opportunity to live in the great Northwest.
Send resume to:
Mr. E. H. Cooley, President
Precision Castparts Corp.
4600 S. E. Harney Drive
Portland 6, Oregon

REPRESENTATIVES WANTED
EXCLUSIVE TERRITORY
An unusual line of equipment for all production facilities in the Foundry Field.
Territories available:
Ohio
Pennsylvania
New York
Illinois
California
Michigan
You will find an amazingly profitable opportunity with this rapidly expanding organization. If you wish to expand your line or are currently selling in this field, contact us at once. **Send resume of your business history to Box H-102 H, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRYMEN
when you need SUPERVISORY or TECHNICAL men why not consult a man with actual foundry experience plus 15 years in finding and placing FOUNDRY PERSONNEL.
Or if you are a FOUNDRYMAN looking for a new position you will want the advantages of this experience and close contact with employers throughout the country.
For action contact: John Cope
DRAKE PERSONNEL, INC.
29 E. Madison St., Chicago 2, Illinois
Financial 6-8700

POSITION WANTED

SALES ENGINEER, mid-thirties, desires position with foundry or pattern shop in sales or supervisory capacity. Able to quote patterns and engineer castings. Knowledge of steel, malleable, gray iron, and non-ferrous castings. **Address Box H-107 P, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRY MANAGER — High production gray iron and malleable iron experience. Extensive automotive background primarily, also broad experience in large agricultural and air conditioning castings production. Managerial capacity and experience. Engineering and accounting education. Recently returned to U. S. after serving as General Manager foreign operations. **Box H-100 P, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOR SALE

FOR SALE — Complete small Shaw foundry — melting furnace — bake-out oven — alloy steels — refractories — chemicals — ready to set up and produce castings up to 40 pounds — list on request. **Charles Zapf & Co., 2423 Main St., Evanston, Ill. DAVIS 8-0333**

QUALITY EQUIPMENT
SAVE AT LEAST 50%
Blast Cleaning
15" cont. Wheelabrator Tumblast
36" x 42" Wheelabrator Tumblast
72" Wheelabrator Swing-table
Furnaces
1000# Swindell Direct Arc Mltg.
3000# Detroit Ind. Arc Mltg.
50 KW to 200 KW Tocco Ind. units
210 KW Lindberg Heat Treat
Sand Mullers
Simpson #3, U.D., 30 cu. ft.
Simpson #2, U.D., 14 cu. ft.
Complete stock of foundry equipment. Send for free illustrated catalog.
UNIVERSAL Mach'y & Equip't Co.
Box 873, Reading, Pa. FRanklin 3-5103

FOR SALE
Reda Furnace, 1000 Series, Like New
Jensen Bros. Mfg. Co., Inc.
Coffeyville, Kansas

Detroit Rocking Indirect Arc Electric Furnace Type LFC, 125 KW, Capacity 350 lbs. cold scrap, 500 lbs. of molten metal. Two shells, complete with automatic electrode control, main control panel and power transformers for 12,000 volt primary power supply. All equipment used very little and in excellent condition. Immediately available. Make offer to: **Box B-111 S, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

The Editor's Forum . . .

A new stature and status . . . have been awarded the AFS Training & Research Institute. The Federal Government has officially recognized T&RI as an organization operated exclusively for educational and scientific purposes. With this recognition comes exemption from Federal income tax; also contributions are tax deductible by donors—as are bequests, legacies, devises, transfers, or gifts.

This government action has provided the metalcasting industry with a much needed transfusion that brings long needed stimulation to education and research. Our industry has been criticized from within and without for many years because it ranks among the lowest in per cent of sales dollar going back into research; applied foundry technology is being removed from the curricula of most engineering schools; and the rapid pace of new technology is fast obsoleting past experience and education.

Much needed leadership in all these weak areas is now being provided by the T&RI program. With the added strength of this government decision we can look forward to a vigorous and growing metalcasting industry in the future.

New Material—100 years old . . . is called polyurethane and is stirring a lot of interest in foundries around the country. What is it? It's an elastomer which is compounded, mixed, poured as a liquid, and heat cured. Then it has all the properties of rubber, only better. Polyurethane is unaffected by oil or air and can stand temperatures up to 275 F. Mix variations can produce a hardness range of 30 to 90 durometer. Wear resistance is phenominal—5 times that of rubber, according to claims. H. A. Burton, Canadian Steel Foundries Ltd., tells of sand slinging 7500 molds without any indications of wear on a urethane coated pattern. (See MODERN CASTINGS, July issue, p 72). Yet an epoxy resin pattern failed to stand up for 300 molds.

Dick Olson, of Dike-O-Seal, has made polyurethane contoured squeeze heads. Molds are harder than when using wood. Auto Specialties Mfg. Co. has made bearings out of this new synthetic for their roller conveyor leading from mold blowing line. Abrasive grit and heavy loading combined to wear out previous bearings in weeks. So far, polyurethane hasn't shown a sign of wear.

The potential applications in the foundry are legion—especially since it not only resists abrasion but absorbs sound like a sponge. Here are just a few spots I can think of where this material should work wonders.

1. Liners for tumbling barrels and blast cabinets
2. Blow tubes for core blowers
3. Work table tops
4. Lining for pneumatic sand conveyor pipes and elbows
5. Lining sand and casting hoppers
6. Dampening noise on shakeout grids and jolt-squeeze machines.

And I'm sure you can think of more. If you want more information on this latest wonder-material just write.

Electronic tattle tale . . . that's what you might term many a modern quality control tool today. Nick Kowall at Pratt & Letchworth Foundry showed me recently how they use a recording watt meter to monitor every batch of sand mixed. A wiggly red line on an electronic recorder tells when each ingredient is added and how long a time the mix is mulled. The operator has an exact time schedule to follow for each sand mix used in the foundry. Power consumption of the muller motor climbs as each ingredient blends into the sand. Usually at point of maximum power load the sand has developed maximum toughness indicating uniformity.

The recorder is located in the sand lab where it can be conveniently watched. Nick doesn't know how they ever got along without this innovation. Scrap caused by improperly mulled sand is now practically unheard of. If you want the name of the manufacturer of the electronic gizmo just drop me a line.

P.S.—Here, in 1861, when this foundry was known as Buffalo Malleable Iron Works, the first crucible steel castings in the United States were poured.

Jack H Schaum

Circle No. 136, Pages 133-134

"SPEER KOSTKUTTER* RODS Result In Substantial Savings Over Conventional Cutting Carbons"

—says Ted Gibson, cleaning room superintendent, West Michigan Steel Foundry, Muskegon, Mich.

"Their interlocking feature eliminates the loss of 2½" stubs and the need for special steel sleeves to form conventional cutting carbons. Speer rods also enable us to remove more waste metal for every dollar spent on carbons. And that's not all...

"Speer shows an enlightened attitude toward their customers' needs, as exemplified by the fact that they have been the *first* to come up with improvements to help us with our metal-removing procedures and lower our manufacturing costs. In addition, Speer's *direct* methods of sales and service save us the middleman's markup."

Reasons like these are why more and more foundries are switching to Speer Kostkutter Rods for their cutting carbon needs. They like the convenience and the way the rods' interlocking feature virtually eliminates stub waste and keeps heat away from the clamp for longer torch life.

Only Speer makes genuine Kostkutter Rods. Get them in diameters of ½", ⅝", ¾" and 1".

*Patent applied for

SPEER Carbon Co.
Carbon Products Division • St. Marys, Pa.

Circle No. 157, Pages 133-134